

# THE LIFE AND LEGACY OF PROFESSOR JOHN SENDERS

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## ABSTRACT

This session looks to serve the purpose of recalling and recounting the life and contributions of Professor John Senders. The contributors to this session include his direct colleagues, his students, his co-authors, those whom he inspired, and even members of his family. These designations are not exclusive! Senders made so many contributions across virtually a century of his lifetime that we are constrained to provide only selective highlights in this memorial session, such as John being named the winner of an “Ig-Nobel” Award. We shall each survey particular works which influenced us, but interweave those observations with personal experiences that can serve to reveal John the character, who was so much more than the simple written record that he has left behind.

### **P.A. Hancock:** *The Quality of Scholarship is not Strained: John Senders and the Life of Inquiry*

Well before I ever met John Senders I was very aware of his reportedly ‘fearsome’ reputation. He was not one, I understood, to suffer ‘fools’ gladly or even at all. My first personal encounter with him was to set our communication style for all of our subsequent interactions. It occurred at a meeting in the mid-1980’s in which he asked me a pointed question concerning a specific topic upon which I had been presenting. The topic itself is not germane here, however, the tenor of the exchange is pivotal. The paper was on a content area in which I had extensive knowledge for, after all, I had completed my doctoral dissertation on it a mere two years earlier. Like a subsequent interaction that I had with the late Richard Gregory, John and I ‘went at it a bit,’ no intellectual quarter being asked, and none given. But there was no malice, no antipathy, no real emotive intent, other than a bit of friendly intellectual sparring. It proved to be my litmus test and, as John and I interacted and even published together in later life, I like to believe that I passed the test. As with the interaction with Gregory, some of the witnessing individuals in the audience were appalled by the vehemence of the interchange. Others were privately, but only privately, pleased that someone had ‘stood-up’ to Senders! They told me so, but only later and out of John’s earshot! I myself was left with a very different feeling. For, I had made a vital connection. Here was a man who above all, wanted to ‘know!’ The superfluous flummery of academia and associated professional ‘hubris’ had been essentially burnt away such that the pure flame of inquiry shone bright within him. I was drawn in immediately. Here was a kindred spirit and a mentor that I knew would be

of untold value. John and I met at the break, he was kindness itself; acknowledging my scholarship and, in quintessential John fashion, filling in some information that I had not known. Indeed, John had been acquainted with one of the three participants in the study that our contentions had been about! However, as Norbert Wiener’s paperboy, this knowledge might not have been surprising for one such as John. I was captivated and it was a moment I shall never forget.



**Figure 1:** *John Senders in a typically pugnacious stance. Although not from Missouri, the “show me” spirit is still very much to the fore here. It is of more than passing interest to match John’s age here to the technology which surrounds him.*

John and I quickly developed a rapport that included, at that time, a mutual interest in the assessment of cognitive workload. He was kind enough to provide a poetic assessment of the measurement problem that subsequently appeared in the text edited by Najmedin Meshkati and myself (Hancock & Meshkati, 1988). His final stanza: “*mental workload is a gyrating vector, in multidimensional space, with an input detector and output selector, one can fit any possible case,*” resonates today in the still unresolved methodological and measurement issues in this difficult but vital area (and see Hancock & Matthews, 2019). Finally, it was the area of driver distraction in which we published mutual work (Hancock, Mouloua, & Senders, 2008). We subsequently had the opportunity for further interaction as a result of the first of what is now a series of conferences on Driver Distraction and Inattention. Over the intervening years we talked extensively on the issue of attribution. It was perhaps the final topic of John’s thoughts concerning the important dimension of road safety to which he contributed so much.

#### **T.B. Sheridan:** *Reminiscences*

John Senders was one of a kind: a brilliant, articulate, provocative curmudgeon. For me he was also a respected colleague and personal friend for over 50 years, and it is too bad to have him pass, even at age 99! I have many fond memories of John, including several international research meetings on human error, mental workload and other topics that John and our late great friend Neville Moray organized. These were unfailingly held at exotic venues like Bellagio Italy, Mati Greece, and John’s own house at Columbia Falls in Maine. At all these meetings intense discussion was always followed by lively and liquid parties that included musical renditions by John and Neville singing in harmony. Who else among us has the hutzpah to convene an international meeting at one’s own home?

Perhaps John’s most famous research project was on driving safety, which John-as-driver-subject demonstrated for various terrified newspaper reporters sitting in the back seat while driving on a Boston freeway. He wore a helmet contraption on which a visor blocked his view except for repeated brief visual samples of the road ahead ([www.youtube.com/watch?v=kOguslSPpgo](http://www.youtube.com/watch?v=kOguslSPpgo)); it was the work for which he won his “*Ignobel Prize*.” The idea was to measure how fast a driver could go as a function of the time between looks. A less courageous laboratory experiment, which I have often cited, measured visual sampling of many simultaneous displays, each of which changed at different rates. This work nicely demonstrated that subjects tend to follow the ideal strategy of sampling in proportion to the display’s rate of change. Though John may have intimidated a few shy colleagues, I found him to be great fun and always having something interesting to say. The spirit of John Senders should live on in the Human Factors community. I sure hope so.

#### **G.M. Hancock:** *A Life of Science and Service*

In the present commentaries, John Senders has been referred to as ‘fearsome’ and ‘curmudgeonly’. However, I am strongly of the opinion that this ‘fearsomeness’ is unwarranted given that it was solely couched in laudable personal and professional characteristics: a broad knowledge and interest base, resolute and solidly-founded convictions, and a great attention to detail. Possessing these attributes, he also encouraged them in others given that John always expected to get as good as he gave.

However, for all that he was a formidable scientific discussant, he was extremely generous with his knowledge. John was always, not only willing, but enthusiastic about sharing perspectives, ideas, and data with others – particularly students. Indeed, at a guest lecture delivered at my alma mater, John threw out multiple research questions that he had been developing and specifically encouraged students to use them freely for their theses and dissertations! Such was his personal and scientific generosity. This session will only scratch the surface of a long and fascinating life.

#### **A.J. Sellen:** *Life with John*

Growing up with John was both a challenge and a privilege. When I was 13, our families were joined together. John found that he had instantly acquired three extra teenagers to add to his own two teenaged boys. It was not easy for any of us: we offspring would simply not comply with his rules and regulations. And as my brothers will agree, I was especially willful, rebellious, and argumentative. But it is to his credit that throughout this stormy time, John always made sure I knew that I was his daughter, that he would stick by me, and more than this, that I could follow in his footsteps.

Catching me at a formative time in my life, John taught me to see the world through his eyes. And what an unusual view that was. Everything could be modelled mathematically. He taught me control theory by balancing a dowel on the end of his finger, queueing theory when waiting at the bank, and information theory when teaching me to drive. The world could be made tractable this way, and human behavior the biggest puzzle to solve. Humans interacting with complex systems (nuclear power plants, aircraft, cars) presented an even bigger and more exciting set of challenges. We both loved to discuss how this might be done.

And he opened up the worlds of Psychology and Human Factors to me through his many friends and huge social network. He introduced me to his niece, Elizabeth Loftus, and his friends Richard Gregory, Don Norman, Neville Moray, Patrick Foley, Jim Reason, Danny Kahneman, Gus Craik, Bob Lockhart and Paul Kolers, as well as the illustrious members of this panel, to name just a few extraordinary people. It began to occur to me that John was opening doors for me that few other people got to step through.

I have known for some time that I have led a life of intellectual privilege because of John, and that he set me on a career path not quite in his footsteps (who could do that?) but following as closely as I could. However, looking back at life

with John, most of all I will remember the laughter. We once wrote an article for Human Factors postulating the existence of an endogenous random human error generator which responded to exogenous forces, raising or lowering its frequency. This was a serious piece for which we presented statistical evidence. However the title, “Two Sources of Human Error” by Abigail Sellen and John Senders, perhaps set the tone of the article, and I can also recall the acknowledgements section that John drafted: “*For any errors in this manuscript, each author cheerfully blames the other*”. The article was rejected, never seeing the light of day. But the fun we had writing it is the legacy I treasure the most.

#### **B.D. Sawyer:** *How Pleasant to Know Dr. Senders*

“A hotel room will be unnecessary. I shall stay at your home.” John Senders exuded importance, only in part through his extraordinary transatlantic accent. I paused, considering. The talk he was to give sounded fascinating, “*The Application of Human Attention to Insect Hunting*”. I was excited our student chapter had acquired a speaker so renowned. As a fledgling scientist and engineer, I was also somewhat intimidated by a man accomplished in both, at a time when my parents were yet in diapers. Further, my wife and I had never hosted a houseguest over 60; John was over 90. I briefly considered where one acquired non-slip shower mats.

“*My wife, of course, shall accompany me.*” intoned John, sensing my hesitance and, characteristically I was to learn, doubling down. It worked, to everyone’s benefit. John and Ann were great fun as houseguests. Thinking back, my wife Szuhui and I find a trove of pleasant moments; BBQ on the back lawn as John recounted how hearing aids were critically flawed. Ann explaining to us John’s unique progression from engineer to professor to getting his PhD from his own student. John showing me how I’d been underestimating queuing theory. Szuhui recalls being deeply impressed as John deftly deployed his considerable charm toward airline customer service, securing a free change of his flight schedule. We attended APA, where John wore me out walking all over a vast Orlando conference center to see talks I might never have attended. That evening, as I rubbed my feet, Szuhui said what we were both thinking.

“*He’s 92. I have no sympathy if you can’t keep up with him.*” There was no more talk about shower mats. We instead talked about how to make it to our 90s, and how to continue to be as engaged and excited about the world as were John and Ann. John and I remained in touch, and he was generous to me with his knowledge and time. Reading over our email correspondence, I am struck by this thought: John was an excellent mentor. He was a great partner in roughing out a good idea, and in rubbing out a bad one, often in the same conversation. He taught me to own the sometimes awkward space between Psychology and Engineering, and encouraged me to ask hard, seemingly unknowable questions. Indeed, this led to him joining my dissertation committee in asking hard questions, including one he called ‘trivial’ which I am still engaged in proving knowable.

John’s seeming immunity to age’s advance impressed immediately, but for me a more extraordinary thing came later, when age began to show some purchase. While at MIT doing my postdoc, John, a Harvard man, came by his old stomping grounds. He gave a talk on “*What older drivers see*”, but what he really wanted to talk about was his newly acquired walker. Crucially, he pointed out, first to me and later to the audience, its utility lay not in mechanical assistance. Instead, the mere presence of this support, of his hand upon it, allowed him to walk again. Even one finger would suffice. Might, he mused, a walker that was pure illusion work just as well? Might the fundamental function of a walker be that not of providing support, but of freeing the mind from hesitation, from fear of the next step? In this, in a very pure form, is what I most enjoyed about John Senders. Life, to him, was a bold exercise in curiosity leading to discovery. John was fascinated as a lifestyle, and every step on his journey reflected this in a manner unflinching and opportunistic. Whatever comes at the end of life, I believe John met it with interest.

Human connections are the best feature of what time we have available. The beginning of my career overlapped the end of John’s, and I am grateful... but also, selfishly, feel cheated. As much time as he had, I wanted more. I know I share that sentiment with many, and it is a testament to the man, to how irreplaceable he seems. How lucky we all are to have known John Senders, to have had him in our community, to have still with us the written record of his investigations and musings. John doubled down, and it worked. I remember clearly watching him on youtube, the pneumatic visor snapping down over a much younger John’s face, listening to his breath on the phone line. “*We’d be delighted to have you,*” I replied. And so we were.

#### **J.D. Lee:** *A Passionately Curious Person*

My advisor, Neville Moray, introduced me to John Senders over 25 years ago through John’s work on human error and models of monitoring behavior (Senders & Moray, 1991; Senders, 1964). Later, Neville introduced me in person and I learned more about his wide-ranging interests and the pure enjoyment he took in thinking about and modeling the world. Both he and Neville brought an attitude of fun and curiosity to research that so often gets lost in the pursuit of funding and publications.

Despite, or perhaps due to, his curiosity-driven science John Senders has had an enormous influence, to the point that many building on his work might not even realize it. For example, his seminal work on visual sampling in automobile driving provides the theoretical basis for the occlusion task used to assess driver distraction (Senders, Kristofferson, Levison, Dietrich, & Ward 1966; Foley, 2008; Gelau, Henning, & Krems, 2009). More generally, his approach to human monitoring behavior anticipated the current challenge with vehicle automation: drivers of increasingly capable vehicles pay less attention to the road as the automation becomes increasingly more capable, making the occasional catastrophic outcome more likely (Merat, et al., 2018).

John’s curiosity kept him developing new ideas that he

passionately advocated. A few years ago, while visiting the University of Toronto, John had me over to his house to share some ideas for understanding the consequences of self-driving cars. He argued that one should create a city simulation that would reveal the emergent behavior of traffic streams composed of automated and conventional vehicles. I had to smile when later that year a colleague invited me to contribute to an NSF proposal to pursue a similar idea. Sadly, his impassioned discussion of how to simulate a city of automated vehicles cut short the explanations of all the innovations he had built into his kitchen.

Earlier this year, as he drew close to his hundredth birthday, we had a long conversation about how best to secure funding to investigate attribution theory and automobile collisions. He correctly reasoned that younger drivers expect older drivers to drive like themselves and vice versa, leading to inappropriate expectations and crashes. By the same logic, drivers expect automated vehicles to drive like themselves and these mismatches explain many recent crashes experienced by automated vehicles. From my initial introduction to John, through to my final conversation, his passionately curious approach to life left me both daunted and inspired.

**P.M. Sanderson:** *Memories and Appreciation of John Senders*

It is hard to believe that John Senders is no longer with us. I was a student of John's in the Department of Industrial Engineering at University of Toronto, in the early 1980s where he was offering graduate seminars in human factors and human-machine systems. In the sure knowledge and confidence of future earnings in consulting and contract research, John had voluntarily gone on half pay so that Neville Moray could be hired at the university.

I took graduate seminar courses with John. Fresh from Australia, I was not used to the transatlantic Cambridge MA accent. In the first lecture I was mystified by John's references to human error. Only later when doing the reading did I realize he was saying human error.

My first human factors investigations drew closely from John's work, as well as from others examining human factors of advanced technical systems. Through John and others, I was exposed to the idea that behavior could be described with quantitative models. My first two conference papers were presented at the Human Factors Association of Canada in 1982. Jackson, Kennedy, Moray, Sanderson, Shiff, and Ting, (1982) reported a quantitative model for how a human operator would share a monitoring task with a computer, and Shiff, Sanderson, Jackson, Kennedy, and Ting (1982) reported an experiment to test the model. Both papers cited John's early work (Senders, 1955; 1964) in which he had developed and tested quantitative models for process monitoring tasks, but monitoring performed solely by the human. In his work, John showed that the bandwidth of a signal, and the required precision for monitoring that signal, would determine how often observers would look at the signal and for how long. Along with the precision and elegance of the modelling, a notable feature of the original studies which

were done in 1953 and 1954 was the use of eye-tracking, the analysis of which was painstaking in those days. John was a pioneer in the analysis of eye-movements as an index of attention allocation, just as he was a pioneer in so many other areas.

While at the University of Toronto I was also introduced to the social side of academia, and there John shone equally brightly. A highlight was the appearance of the Three Tenors on notable occasions—John, Neville Moray and Pat Foley singing barbershop quartet-style songs, often crafted for the event.

In later years I got to know John and Ann better. They stayed with Neville and me in Illinois and also visited my family in Australia on two occasions while I was living in the USA. My family has fond memories of John spending most of one day on a long-distance phone call, in those pre-internet days, working through some urgent contract business that had emerged back home, my family supplying him with food when mealtimes rolled around—but the family also enjoying John's gourmet cooking once he was off the phone. More recently, when John and Ann visited Brisbane, John held my students spellbound with stories of the early days of human factors and his work on manned spacecraft and patient safety.

So when John's 90th birthday came around in 2010, and University of Toronto's Department of Mechanical Engineering hosted the Celebration of Applied Human Factors Seminar in honor of Professor John Senders, it was an easy decision to make the trip.

A video made last year "John's story—The science of error" (Back Lane Studios, 2018) provides a delightful first-person insight into John's life and times in science. My final interaction with John was also via video, in August 2018 when John, with Abi Sellen's assistance, made a short video recording for a special session at the IEA in honor of Neville Moray. John's video, made at the age of 98, showed him as gracious and assured and his voice as resonant as ever.

**P. Milgram:** *Former Student and Long-Time Colleague*

My first memory of John Senders coincides closely with the image of him conveyed in Figure 1, standing next to his beloved analogue computer, at a University of Toronto open house. A significant deviation from the depiction in the photo, however, is that John was balancing a broomstick at the time, while simultaneously waxing eloquent to anyone who would listen on the multifarious facets of human information processing that could be deduced through the analysis of such a 'simple' task. (Arguably more significant than that first impression is that I have often repeated that exact same performance in front of my own classes over the years – needless to say with attribution to John).

Although I join my colleagues on this panel in acknowledging how abundantly pleased we all are to have learned so much from John, I am proud to go one step beyond that in proclaiming that I am the only one among us who was actually one of John's official graduate students. Needless to say, having John Senders as a PhD supervisor was a 'unique' experience ... and a source of more unforgettable escapades

than space permits me to summarize here. I'll state simply that John reminded me on more than one occasion that his primary criteria for accepting a graduate student were that the candidate be able to cook and to speak German. As mention was seldom made of prior academic achievements, I was never really sure whether or not being accepted by him was actually a compliment!

One relevant anecdote related to John's own formal academic accomplishments was his resolution that, before he officially retired from the University of Toronto (needless to say, he never really 'retired' from anything!), he wanted to obtain a PhD degree. This was a consequence of an earlier remark made by his longtime colleague Andries Sanders, at the University of Tilburg in the Netherlands, who had informed John that it was possible to earn a PhD degree based on one's accumulated research, without having actually to put in time as a full-time student. This led to the momentous gathering in September 1983, with Ann and me standing on either side of him as his 'paranymphs,' at which John succeeded in effortlessly convincing a visibly intimidated jury of 'examiners' (it was debatable who was examining whom) that, on the basis of his 3 decade long research on visual scanning behavior (Senders, 1983), he merited the title of 'Prof. Dr.' He formally retired from the University of Toronto shortly after that. [As a side note, it was very difficult explaining to my Dutch colleagues how it was possible that I had served as a paranymph at the 'promotie' (PhD examination) of my own 'promotor' (PhD supervisor)].

I shall conclude (for the moment) by pointing out John's dedication towards preserving the tradition of the 'academic family tree'. With his own academic genealogy having been traced back to about the year 1000 (AD!) in Constantinople (Kristensson, 2010), John devoted very much overt 'paternal' love towards nurturing his 'academic grandchildren' (occasionally recognized by some also as my students). One memorable manifestation of this devotion was the time I introduced him to one of my recently accepted graduate students. Without hesitating (and without waiting to be asked), John immediately proclaimed "I shall be delighted to serve on your PhD committee!" Remarkably, John's close individual relationships with many of those former graduate students continued to the end of his momentous life, a testament to his powers of inspiration and his generous spirit.

## REFERENCES

Back Lane Studios "John's story—The science of error". Retrieved: 3-8-19.. <https://www.youtube.com/watch?v=71Xn4IG1Qp0>

Foley, J.P. (2008). Now you see it, now you don't: Visual occlusion as a surrogate distraction measurement technique. In: Regan, M.A., Lee, J.D., and Young, K.L. (Eds.). *Driver Distraction: Theory, Effects and Mitigation*. (pp 1123-133), Boca Raton, FL.: CRC Press.

Gelau, C., Henning, M.J., & Krems, J.F. (2009). On the reliability of the occlusion technique as a tool for the assessment of the HMI of in-vehicle information and communication systems. *Applied Ergonomics*, 40 (2), 181-184.

Hancock, P.A., & Matthews, G. (2019). Workload and performance: Associations, insensitivities and dissociations. *Human Factors*, in press.

Hancock, P.A., & Meshkati, N. (Eds.). (1988). *Human mental workload*. North-Holland: Amsterdam.

Hancock, P.A., Mouloua, M., & Senders, J.W. (2008). On the philosophical foundations of driving distraction and the distracted driver. In: Regan, M.A., Lee, J.D., and Young, K.L. (Eds.). *Driver Distraction: Theory, Effects and Mitigation*. (pp 11-30), Boca Raton, FL.: CRC Press.

Jackson, R. Kennedy, S., Moray, N., Sanderson, P.M., Shiff, B. & Ting, L. (1982). A model for the allocation of man and computer in supervisory control. *Proceedings of the 15th Annual Meeting of the Human Factors Association of Canada*, Toronto.

Kristensson, P.A. (2010) *My Academic Genealogy*. <http://pokristensson.com/academicgenealogy.html> (accessed 12/03/2019)

Merat, N., Seppelt, B., Louw, T., Engström, J., Lee, J.D., Johansson, E., Green, C.A., Katzaki, S., Monk, C., Itoh, M., McGehee, D., Sunda, T., Unoura, K., Victor, T., Schieben, A., Keinath, A. (2018). The "Out-of-the-Loop" concept in automated driving: proposed definition, measures and implications. *Cognition, Technology & Work*, 1-12, doi.org/10.1007/s10111-018-0525-8.

Senders J.W. (1955). Man's capacity to use information from complex displays. In H. Quastler (Ed.), *Information Theory in Psychology*. Glencoe, IL, The Free Press.

Senders, J.W. (1964). The human operator as a monitor and controller of multidegree of freedom systems. *IEEE Transactions on Human Factors in Electronics*, (1), 2-5.

Senders, J.W. (1983). *Visual Sampling Processes*. Drukkerij Neo-Print, Soest, Netherlands.

Senders, J.W., & Moray, N.P. (1991). *Human Error: Cause, Prediction, and Reduction*. Hillsdale, New Jersey: Lawrence Erlbaum Associates.

Senders, J. W., Kristofferson, A., Levison, W. H., Dietrich, C. W., & Ward, J. L. (1966). The attentional demand of automobile driving. *Highway Research Record*, 195, 15-33.

Shiff, B., Sanderson, P. M., Jackson, R., Kennedy, S., & Ting, L. (1982). An experiment of the behavior of man and computer in supervisory control. *Proceedings of the 15th Annual Meeting of the Human Factors Association of Canada*, Toronto.