

The Establishment of HFT and the Early History of Human Factors in the Telecommunication Industry

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John Karlin during his HFT 2003 Keynote Speech in Berlin
(photo: Bruno von Niman, taken with an Ericsson P800 mobile smartphone)

1. Introduction: Ed Israelski PhD, Chairman

I'm Ed Israelski. I'm a member of the HFT permanent steering committee PSC. I've been a member since 1995 and I can trace my membership back to Dr. John Karlin, who you'll hear describe in some detail the origins of HFT as well as human factors in the standards world, which was the CCITT now ITU. I had taken my PSC position from Charlie Rubinstein also of Bell Laboratories who in turn took over when John Karlin retired. I'd just like to say a few words of introduction about John Karlin, who was one of the founding members of this organisation in 1961. Cambridge, UK was the first meeting location and now we're at our 19th meeting in Berlin. So we have a long and interesting history.

John received his PhD from the University of Chicago, where his doctoral thesis was on a factor analysis of auditory function. This was the first factor analyses of any sensory function. His PhD was in experimental psychology, but he has engineering origins, having a science and engineering bachelor's equivalent from the University of Cape Town in South Africa. After his PhD at the University of Chicago, John worked at Harvard University as a Research Associate under a famous psychologist, S S Stevens, Director of the Psychoacoustics' Lab. He was there from 1942 to 1945 where he also studied some additional electrical engineering at MIT. We will hear in John's description of this very close connection of practical engineering and applying psychology.

In 1945 John joined Bell Laboratories and started what we think is the first industry human factors group, at least in the USA. Many of us here may have wondered who started human factors in industry after World War II, where there were many psychologists working on military systems. In industry after the war John Karlin was the first at Bell Laboratories, AT&T Bell Laboratories at the time, when there was the Bell system. He expanded human factors quite dramatically while there, retiring in 1977. From 1951 to 1977 John was the department head of human factors engineering, and you'll hear more about that.

Other accolades are that John is a Fellow of the IEEE Institute of Electrical and Electronic Engineering. John is also a Fellow of the American Psychological Association, division 21, the division of applied experimental psychology and engineering psychology. John is a Fellow of the Human Factors and Ergonomics Society and he was awarded by that same society, the Jack Kraft Innovator Award in 1970 for expanding human factors to new areas such as telecommunications and providing innovation. That is a little bit of background about John.

I owe a lot to John myself; I had the pleasure of working for him from 1973 to 1976. I joined Bell Laboratories with an electrical engineering background and learned about John's human factors department. John let me come in there on a trial basis for one year as an intern. And it seemed to work out because I then spent 28 years at Bell Laboratories. And I enjoyed that very much. I got my PhD in human factors because I saw that this was the field that I wanted to spend my career in. One interesting thing I noted in an interview with John published in a book by Ed Klemmer of Bell Laboratories, who some of you may know. Ed Klemmer's book is titled "Ergonomics: Harness the Power of Human Factors for Your Business".

In one of the chapters is an interview with John, and in it there is some interesting background, which you will hear more about. But there was a quote that I liked. The quote came as John was recounting the reasons for his success at Bell Laboratories including growing Human Factors from one person to over 200 at the time of his retirement, when he noted: “that you should always hire people smarter than you.” And John hired me, so ...

I think without further ado, I would like to introduce Dr. John Karlin.

2. Prologue

Before I start this saga, I would like very much like to thank you all for the great honour you have done me in naming the award for the best paper at these meetings after me. I can really think of no more fitting way by which I would like to be remembered. I would also like to thank the Permanent Steering Committee for inviting me to come here and tell you all how you were born. I must say I was somewhat surprised to get this invitation; I've been retired for more than a quarter of a century from human factors work. I can only assume that somebody on the Permanent Steering Committee must have an ongoing strong interest in dinosaurs. But I understand that every professional organisation needs to have some kind of record of how it got started and I hope that the transcript of this talk plus some other things that I will mention in the next few minutes will help provide that for this organisation, as it deserves one. And I thought to myself when I got this invitation, you better do this now because by the time of the next meeting you too, like the dinosaurs may be extinct.

This talk will be principally about the symposium, but I would also like, at the end, to have a short presentation on how the first human factors working party was established in ITU (CCITT at that time). The same people were involved in both efforts pretty much and the problems studied were very much the same, and there was strong interaction between the two groups. On the hand-out that has been given out, I have listed a number of related organisations which I think were important factors in the establishment of the first symposium [ed: see Appendix].

What I'm about to say is, of course, from the viewpoint of somebody who's entire working career was spent in the United States and I'm sure there was a lot of good human factors work going on in telecommunications elsewhere that I had no way of knowing about. And as we go along and after my talk if you would make notes on the space provided about other activities, which ought to be on the record as being helpful in establishing the first symposium, I wish you would do so. And then if you would return this to Ed Israelski, he will get it to me. When I edit the transcription of this talk I'll incorporate your additional information that you might provide.

3. Pre-Human Factors period: 1900 - 1940

The first symposium in May 1961 in Cambridge, England, did not just suddenly jump up out of a vacuum. Telephone administrations and Manufacturers had to be convinced at that time, that there was a need for such a symposium and that there would be a benefit to sending their people there. And so I think I would like to try to trace briefly some of the important milestones, which I think helped, set the stage. As

I saw it, the history of human factors in industry really is quite ancient. It goes back at least 100 years. There was the work that was done before the war, 1900-1940 or thereabouts, there was some very good human factors work in industry and also in telecommunications but none of it was done by people trained in human factors. It wasn't until after the war, that as far as I know, the telecommunications industry hired its first full time human factors person. And again as far as I know, that person happened to be me.

3.1 Time motion

So let us look first of all at what I am calling the pre-human factors era, from 1900 to 1940, when the human factors work was done by people who were not trained in the human factors experimental psychology discipline. There are three classic studies that I will mention that typify the very good work that took place at that time.

The first one started in 1900 by Frank Gilbreth who invented the Time and Motion studies. I'm sure you know all about that. His first study had to do with brick layers in the building industry. He himself was a brick layer. As far as I know, he never went to college or university. He certainly had no human factors training.

3.2 "Hawthorne effect"

The second study was a five year study from 1927 to 1932 which was done in the Hawthorne Works in Chicago, Illinois, where the Western Electric Company at that time did all the manufacturing of telephone equipment for the Bell System. Talking about dinosaurs, you do remember the Bell System, don't you? They wanted to see what could be done to increase the productivity of women workers on the production line for telephone relays. They conducted a number of studies improving, for example, the lighting, decreasing the noise and so on. And whenever they did that the productivity went up. And they began to feel pretty good about that until one day, by chance; somebody turned the lighting down so that it was worse than normal. Productivity went up again. So the lesson that was learnt from that study was not what they expected. They discovered the so called "Hawthorn effect" so well known now, which was that when people have a boring job, like an assembly line, the most important variable is paying attention and making them feel important. This is how they get motivated.

The Hawthorn study was carried out by John Mayo, who was a Harvard Professor in the business school.

3.3 Speech intelligibility

And the third study was in telecommunications directly, from 1927 to 1940 in Bell Labs carried out by Harvey Fletcher and W. A. Munson.. Fletcher was a physicist and director of the physical research department at Bell Labs. And W A Munson was an engineer in Fletcher's department. From 1927 to 1940 they conducted studies to determine the bandwidth, speech level, and signal to noise ratio and non-linear distortion requirements for telephone circuits. And that work established the transmission parameters for the Bell telephone system and for a lot of other places too. That work was continued by many other organisations, specifically D L Richards,

an engineer at Dollis Hill laboratories in at the British Post Office. All of this work was done by people not trained in human factors.

So after the war, we had the situation where, industry was quite well aware of the importance of studying human factors and the benefits to be gained. But they were not, by any means, sold on the notion that you needed people trained in human factors disciplines to do the work. The work had been done by non-human factors people. So the question was, “Do we need human factors people?”

And of course, at that time in 1945, the idea of a symposium like this for human factors people was simply out of the question. For one thing, there were not any human factors people. But never the less, I think the course of the awareness and consciousness that this brought to industry; of the benefits of studying the human factor in the industry; I think that helped a lot in setting up the atmosphere in which human factors people then could add further value.

4. The Human Factors era – 1945 to present

4.1 Bell Laboratories

Turning now to the period after the war, after 1945, and what I am calling the Human Factors era, and in a sense this was, as far as I know, when the telecommunications industry first hired a full time human factors person, that happened to be myself. I went to Bell Labs in 1945 to work with Harvey Fletcher and W. A. Munson on speech intelligibility. I think the fact that I was hired, and could slip through the door, was sort of a lucky break, because after the war they were hiring a lot of people - they hadn't hired during the war - they weren't quite as fussy I guess, but also, of course, and as Ed mentioned, I had an engineering background and they thought “Well, if he has an engineering background he can't be all bad.”

But, I had not been there very long when it became obvious to me that the interface between the telephone system and the subscriber involved a lot more than just speech intelligibility. And so I wrote a proposal to management suggesting that they ought to set up a Human Factors Engineering Department to take a closer more intensive and broader look at this interface. And I made three points. First that this interface involved more than just speech intelligibility and in the future this would become increasingly true. Secondly that the human factor at Bell Labs at that time was very much secondary to telephone research and development; developments came first and then the question was would people like this, could they operate it, and would they need it. But I thought that in the future the user should come first, we should first of all find the user and study his capabilities, limitations, needs and wants. These results that should help guide engineering as to what should be developed. It shouldn't all be the other way round, you should look at both. Come at it from both angles. And thirdly, that to do this I didn't think that engineers, in their spare time could armchair the predictions about people's capabilities and limitations and needs when they had no training in studying or understanding these quantities, and that the solutions that they came up with to problems were not necessarily optimal and in fact sometimes might be wrong.

Well, Bell Labs did adopt my proposal, and in 1947 the Human Factors Engineering Department was set up. It wasn't called that at the time; it had several names as it

developed and got larger but I'm just calling it that now to save time. So, this was a small group consisting of a statistician, a physicist, an engineer and a human factors person, who was myself, with supporting staff. The statistician became the head of that department and he is somebody that perhaps you might recognise by name, it was Walter Shewhart, who was the inventor of the Quality Control Chart. He retired four years later in 1951 and I became head, and I remained head until I retired in 1977. Well, we set out to do some experiments, which would show why a human factor was important and why you needed full time specialists who had a background in understanding people's capabilities, limitations and needs. And we had a series of experiments, a lot of which were quite successful in proving the point. In my time available I will mention a few simple experiments very briefly. If there is time at the end for questions, I would be glad to answer them or during coffee breaks we can talk about things that might interest you.

The first experiment concerned the weight of the handset. At that time the handset weighed 18 oz (504 grams) and we decided to find out what weight people really wanted. Well, the management and engineers couldn't understand why we were doing this. They said, "look, nobody has ever complained about the weight. Why are you studying this?" We said, "Well, we would like to study it anyway." So we constructed a series of handsets, which looked identical with the one they had, and the weight varied all the way from 6 oz (168 grams) through 18, the standard, up to 30 oz (840 grams). These were in logarithmic steps in accordance with the Weber Fechner law. The sets were randomised on a table and we used a stratified sample of people, management, technical, clerical and maintenance. We had 200 people come in and we asked them just to try the sets and pick out the one that felt best for them. Many of them told us that this was a waste of time and they would simply give us the same set that they had in their offices (which was 18 oz). The heaviest set chosen was 12 oz. More people chose 6 oz, which was the lightest, set available. This was a very simple experiment but it proved to be a very important lesson for the engineers and management. It showed, that because people don't complain about something, it doesn't mean that you have an optimal solution and that there are better things out there, and also that you need sophisticated ways to show that. It's not a matter of common sense, in other words people have what we call latent needs, needs that they themselves don't even know about. And they can't know about them unless they have experience with the device. We built a simulator called "Sybil," (after the Sybillan oracles in ancient Rome who could predict the future) which could provide a variety of experiences for people so that they could make valid judgements about what they would like in the future.

The second experiment concerned what happened to the telephone set after the war at Bell Labs. They made the base larger to accommodate more equipment to do more things, so they (the engineers and the outside Industrial Designers who developed it) thought that was a good opportunity to take the numbers and letters out of the finger holes, and put them next to the finger holes on the base. This would make it easier to see the numbers and letters, easier to dial and so on. Instead, in the experiments in the laboratory they discovered that, the dialling time increased by 15%. Well, they just couldn't understand that, so they called me and asked me to come over and take a look. I went over, and I took a look at the set and I dialled a couple of numbers. I could see immediately what the problem was. There were two things wrong with the way they had developed this. The first had to do with the fact that both the base and

dialling wheel were black. In those days you could have any colour you wanted as long as it was black. They had a black wheel spinning on a black background. So it was hard to see when the wheel had come to a rest. Each time you had to listen to the click when it came back at the end, and that increased reaction time. And secondly they had a black hole, with nothing in the hole, so it was more difficult to know where to put your finger; that also increased reaction time. Altogether it increased dialling time by 15%. That would have meant a 15% increase in the central office switching equipment and that was a horrifying thought. So I said to them, "Well, put a white dot in the finger hole." They did that and the dialling time was restored to normal. Well, that made quite an impression, they thought these people who are trained in human factors really know something we don't and maybe we should pay more attention.

To digress briefly, I have a couple of examples that you might find amusing. One had to do with the length of the telephone cord that connects the handset and the base. At that time as I remember, it was about 35 to 40 inches. But after the war there was an acute shortage of the copper that was used to make the cord and Western Electric wanted to know if the cord could be made shorter. So we ran an experiment. And again we did not think it was useful to ask people how they felt about a shorter cord if they have never tried it. So we thought we ought to give them experience. But we didn't want to let them know that they were getting the experience. So what we did, we chose 60 people, again on a stratified basis, from management to maintenance people, and every third day we would go to the offices after work, and we shortened the cord by one inch. Then we waited for people to call the repair department to complain that there was something wrong with the cord or somebody was fooling with the cord. Well, nobody complained until it was 12 inches shorter. And the rest of the people waited even longer.

So, Western Electric was able to go ahead and affect some very significant savings. So that helped show that human factors could pay off in economic terms.

And the last example, concerned 'all number' dialling. Back in the fifties in the Bell system we had seven digit dialling with an exchange name and five digits; people dialled the first two letters of the exchange name. The system was running out of numbers. By dropping the exchange name and dialling 7 numerals, the "1" hole, which had no letters could be used to increase the number of exchanges. This would obviate the need to use 8-digit dialling. It was felt that subscribers could not memorize 8 digits. But, there was still a lot of concern as to whether people could remember and dial 7 numerals. So we were asked to do the experimental work to find out. So we did our experiments and concluded that it would not be a problem and the dialling time and errors did not change significantly.

Well of course today, we would laugh about that. In the United States, even for local dialling, we have 10 digits and we don't think anything of asking people to dial up to 15 digits for calls, and they seem to be able to do it.

When all-numeral dialling was put into service, there was a lot of public resentment. There was also a lot of media attention given to the change, and my name was fairly prominent in the media at that time. One day I was at a cocktail party and I saw some people over in the corner, they were obviously looking at me and talking about me. Finally a lady from this group came over and said "are you the John Karlin who is

responsible for all number dialling?” and as modestly as I could I said “Yes I am” and she said “how does it feel to be the most hated man in America?”

Well, this work did catch on at Bell Labs. In 1947 we had one human factors engineering department with one full time human factors person. By 1966 there were now seven human factors departments at Bell Labs and a total of 350 full time people working in human factors.

4.2 1st HFT Symposium, 1961

Now we come to the events immediately preceding the first symposium in 1961. In 1959 I received visits from two people at Bell Laboratories. The first one was from Jan Schonten, who was head of the Institute for Perception Research in Eindhoven Holland, an institute that was funded by Philips and the Dutch Post Office. They were doing basic research in vision and speech, with the long-range objective of helping television, the picture phone and speech instruments. And he had come to talk to his counter parts at Bell Labs, and while he was there he heard about our work and came over and talked to me about our work. We got to wondering about who else in Telephone Administrations and Manufacturers elsewhere was doing similar human factors work.

I also received a visit from E. R. Floyd who was a Professor of Physiology at the Loughborough Institute of Technology in England and a consultant to the British Post Office. He was travelling in the country and had heard about our work and came to see me. And as a result of that visit, he invited me to attend the meeting of the Ergonomics Research Society in England that year and give a paper on our work. It was at that meeting that I met Ruben Conrad, who was Deputy Director of the Applied Psychology Research Unit in Cambridge, England. He was human factors consultant to the British Post Office, although not the technical communications department, but more on information processing kinds of problems. And as a result of that the three of us, Schonten, Conrad and myself, had discussions and we decided that perhaps the time had come to try and find out whether or not there was a need for an International Symposium of Human Factors people, with human factors interests in telecommunications. And so we constituted ourselves as the organising committee. We put together a letter of invitation in which we suggested that there might be a need for telecommunications people with human factors interests to get together and exchange information to mutual benefit, and that I would have a chance to talk about the growth of human factors at Bell Labs. And we finally pointed out that human factors in industry had already gone far ahead of telecommunications human factors, in terms of the fact that a number of other organisations had become organised to exchange information for human factors in industry.

These organizations were; in 1949 the Ergonomics Research Society was started in England by F K Murrell. In 1956 The American Psychological Association established a new division 21, Society Of Engineering Psychology. In 1958 the Human Factors society was inaugurated. In 1959 the International Ergonomics Society was started. In 1966 The IEEE in America, the Institute for Electrical and Electronic Engineers added a new Society, which was for Human Factors in Electronics. So you see there was a great deal of interest in industry about this, but the telecommunications industry seemed to us was lagging in all of this. And lastly we

thought that such a meeting might produce the kind of standing and prestige that would help establish human factors as a profession in the eyes of telecommunications management.

Well, there was a favourable response and this meeting took place in May of 1961 in Cambridge, England where the Applied Psychology Research Unit was the host. There were 20 papers, which came from 7 countries. And there was a total attendance of conferees of 35. Of the 20 papers only 2 were given by human factors people. That was Conrad and myself. All the rest were given by engineers or members of management. So that was the status of human factors in 1961. Of those 20 papers, 6 came from the UK, 4 from the British Post Office Research at Dollis Hill, 1 from the Imperial College of London and 1 from the Applied Psychology Research Unit in Cambridge. There were 4 papers from Sweden: 2 from the Ericsson Company, 2 from the Swedish Board of Telecommunications. There were 4 papers also from the USA (3 were Bell Labs and one was Automatic Electric, a manufacturing concern). There were 2 papers from Germany (1 from Siemens and 1 from the Technical Institute in Berlin), and there were 2 papers from Denmark (both from the Copenhagen Telephone Company). 1 paper from the Australian Post Office and one paper from the Chilean Post Office.

The papers that were presented even then were quite diverse. There were papers on speech, of course, there were papers on dialling, both on the rotary dial and the pushbutton dial). There were 2 papers on telephone design; one was on a handsfree telephone, the speaker-phone and one was on what I think was the first one piece telephone which was put out by the Ericsson company in Sweden and was called the Cobra phone. It was just one piece that stood up and on the bottom was the dial. There were papers on operator services and transmission maintenance. And there was one paper on international telephone traffic.

The symposium met with a great deal of enthusiasm and a decision was to meet every third year in Europe, and that there needed to be human factors interaction outside of CCITT, so that we would not be tied up with standardisation problems only. The 1961 symposium was held in Cambridge, there were 20 papers with 35 participants. The second was held in Copenhagen, the third one in the Hague, and in 1968 by the time of the fourth conference, which was held in Bad Wiessee in Germany, both the number of papers and the number of conferees had doubled to 42 and 80. And that's how it all got started. See the Appendix for a table outlining all of the HFT symposia.

4.3 CCITT (ITU)

Now, just a few words to tell you about ITU. In 1960 the ITU had three divisions, CCITT, Telephone Telegraph, CCIR radio, and IFRB the International Frequency Registration Board. In 1983 the names were changed to ITU-T, ITU-R and IFRB. In 1964, at the third plenary session in Geneva, ISO the International Standards Organisation, wanted to be assured that CCITT adopted for the pushbutton telephone, the same layout of the numerals 123 on the bottom row. ISO had previously standardised the push button layout for adding machines and calculators. They had the

123 on the bottom row. They had heard that the telephone people were studying the push button layout. So the CCITT adopted a Question on the physical layout of the push button telephone and assigned it to Study Group 13, which was Networks. That study group met in 1966 in New York City and formed the human Factors Working Party which was the first human factors working party in ITU and they gave us this question to study. Dr. Max Schoeffler was, briefly, chairman of that working party and I succeeded him as chairman and remained so until I retired. We divided up studies on the pushbutton layout amongst the various national participants. And in 1967 in Tokyo, at the meeting of the study group, we came back and reported that we could not agree with the ISO, and that all our tests had shown that the best layout was 123 on the top row, both in terms of dialling performance and subscriber preference and expectation. In the process, we investigated many layouts; these included two horizontal and vertical rows of five buttons, duplicating the clock face, etc.

So finally in 1968 at its plenary session CCITT adopted this and so informed ISO. ISO was not able to produce any supporting studies. And that's how it was adopted. At that same session CCITT then assigned a second question to the working party; we were asked what could be done to decrease the confusion that subscribers experienced with non-standard audible signals in international calling.

The working party also flourished, and by 1988, when it reached its peak it had 5 Questions and 25 people in the working party. After that it started to decline for various reasons; these probably included budget restrictions, the growth of ETSI, and increased competition between telecommunications organizations. Companies now wanted to be different for competitive advantage, rather than standardise everything. And the fact that the telephone service now depended much more on software than on hardware and there was less subscriber testing needed.

5. Thank you!

I would like to thank you for giving me this opportunity to talk to you. I found preparing this talk quite stimulating; it brought me out of my hibernation. And now that I've done it, perhaps now that we have a record, I'm happy to go home, to go back into hibernation with the rest of my fellow dinosaurs. Thank you.

Postscript note: I would also like to thank those who provided information important in the preparation of this talk; Drs. Ivan Brown and Reuben Conrad of APRU and CCITT (ITU); Drs. Max Schoeffler, Blake Wattenbarger, Bruce Hanson and John Ryan of Bell Labs. Thanks also to Dr. Anne Clarke who transcribed my HFT03 presentation into this paper that I edited with assistance from Dr. Ed Israelski.

Appendix

Human Factors Telecommunications Symposia History

No.	Site:	Country:	Year:	Host / sponsor(s):
1	Cambridge	GB	1961	None
2	Copenhagen	DK	1963	None
3	den Haag	NL	1966	NL PTT
4	Bad Wiessee	DE	1968	Deutsche Bundespost
5	London	GB	1970	British Post Office
6	Stockholm	SE	1972	Televerket (now TeliaSonera)
7	Montréal	CAN	1974	Bell Northern Research
8	Cambridge	GB	1977	British Post Office
9	Red Bank, NJ	USA	1980	AT&T Bell Labs, Holmdel, NJ, USA
10	Helsinki	FI	1983	None
11	Rennes	FR	1985	France Telecom
12	den Haag	NL	1988	Netherlands PTT, Philips Telecommunications B.V., Philips Telecommunications and Data Systems, AT&T
13	Turin	IT	1990	ISPT, CSELT, SIP (now Telecom Italia), SIXTEL (Olivetti Group), STET, Istituto Bancario S. Paolo di Torino
14	Darmstadt	DE	1993	Deutsche Telekom, Alcatel SEL, Siemens AG, Telenorma, et. al.
15	Melbourne	AUS	1995	Telstra, Telecom Australia, GSA Information Consultants
16	Oslo	NO	1997	Statens Teleforvaltning (Norwegian PTT regulator), Telenor R&D, SINTEF
17	Copenhagen	DK	1999	TeleDanmark
18	Bergen	NO	2001	Telenor R&D, Vodafone, Ericsson

No.	Site:	Country:	Year:	Host / sponsor(s):
19	Berlin	DE	2003	Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut
20	Sophia-Antipolis	FR	2006	ETSI, the European Telecommunication Standards Institute
21	South-East	Asia	2008	Planned