The Promise of Affective Computing

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Abstract—This chapter is adapted from an invited introduction written for the first issue of the IEEE Transactions on Affective Computing, telling personal stories and sharing viewpoints of a pioneer and visionary of the field of Affective Computing. This is not intended to be a thorough or a historical account of the development of the field for the author is not a historian and cannot begin to properly credit the extraordinary efforts of hundreds of people who helped bring this field into fruition. Instead, this chapter recounts experiences that contribute to this history, with an eye toward eliciting some of the pleasurable affective and cognitive responses that will be a part of the promise of Affective Computing.

Index Terms—Affective Computing, Agents, Autism, Psychophysiology, Wearable Computing.

1 Introduction

JODIE is a young woman I am talking with at a fascinating annual retreat organized by autistic people for autistic people and their friends. Like most people on the autism spectrum (and many neurotypicals, a term for people who don't have a diagnosed developmental disorder), she struggles with stress when unpredictable things happen. Tonight we are looking at what happened to her emotional arousal as measured by a wristband that gathers three signals – skin conductance, motion, and temperature (Fig. 1). Jodie was upset to learn that the event she was supposed to speak at was delayed from 8:00 to 8:30pm. She started pacing until her friend told her "Stop pacing, that doesn't help you." Many people don't have an accurate read on what they are feeling (this is part of a condition known as alexithymia) and while she thought pacing helped, she wasn't certain. So, she took his advice. She then started to make repetitive movements often seen in autism called "stimming," and continued these until the event began at 8:30. In Fig. 1 we see her skin conductance on the top graph, going down when she was pacing, up when she was stimming, and hitting its highest peaks while she presents. The level also stays high afterward during other people's presentations, when she stayed up front to handle problems with the audio-visual technology, including loud audio feedback.

Collecting data related to emotional arousal is not new: For example, skin conductance has been studied over a hundred years. What is new, however, is how technology can measure, communicate, adapt to, be adapted by, and transform emotion and how we think about it. Powerful new insights and changes can be achieved with these abilities. For example, Jodie collected her emotional arousal data wearing a stretchy wristband, clicked to upload it into a mobile viewer, and showed it to her friend (the one who had asked her to stop pacing). The first words spoken after checking the time stamps on the data display were his. He said, "I'm not going to tell you to stop pacing anymore." The next morning I saw the two of them again. This time, she was pacing and he sat quietly nearby letting her pace, typing on his laptop. The ability to communicate objective data related to her emotional arousal and activity – specifically her sympathetic nervous system activation of which skin conductance is a sensitive measure, prompted a change in his behavior. Mind you, she had told him in the moment of stress that she thought pacing was helping, but this did not change his behavior. Objective data about emotions carries much more power than self-reported subjective feelings.

The convenience of a new affective computing technology can lead to new self-understanding as it did for Jodie. Objective data related to emotion is more believable than verbal reports about feelings. Shared affective data can improve communication between people and lead to better understanding and sometimes to beneficial changes in behavior: Jodie's friend could now accept that her pacing might be helpful, and let Jodie pace.

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Researchers inventing future products tend to put in features that marketing people can describe to customers. Features such as more memory, more pixels, and more processing power can all be quantified and designed into explicit goals. The saying "if you can't measure it you can't manage it" drives progress in many businesses. Measure it and you can improve it. What if technology enabled you to measure the frustration a product reduces (or elicits) as easily as you measure processing speed increases (or decreases)? Measuring the frustration caused by a technology when it happens could enable engineers to pinpoint what caused the frustration and work to prevent or reduce it. With affect measurement, technology can be designed with an explicit goal to give people significantly better affective experiences.

Technology can also be improved if it has an intelligent ability to respond to emotion. Intelligence about emotion is not easy. For example, you might think it would be intelligent to have a robot smile when it sees its collaborator exhibit the so-called "true" smile that involves both the lip corner pull and the cheek raise. Shared happiness is usually a positive experience, and smart to elicit. However, we recently learned that while 90% of participants expressing delight made this facial expression, so too did 90% of participants in a frustration-eliciting scenario who reported feeling significant frustration. While it might be intelligent to respond to a delighted smile with one of your own, it is probably not intelligent to appear delighted when your collaborator is frustrated if you want him to like you. While recent progress is making it easier to do things like automatically discriminate smiles of delight and smiles of frustration, the effort to work out the situation, its interaction goals, and the personality differences of the participants is not simple. Affective computing has a lot of problems still to solve before machines will be able to intelligently handle human emotion.

Technology can also be improved by virtue of incorporating principles of emotion learned from biological systems. Emotions guide not only cognition but also other regulatory functions that affect healthy behaviors. Many extraordinarily hard challenges in the modeling of and understanding of emotion remain to be solved in order to bring about its benefits.

Attitudes toward affective computing, which I defined in 1995 as "computing that relates to, arises from, and deliberately influences emotion," have changed so much in the last decade that it is now hard for some people to believe it used to be a ludicrous idea. In the early 90's I had never heard of the shorthand "LOL" (Laugh out Loud) but it applied to this research. I beg the reader to let me indulge in some remembrances, starting in 1991, my first year on the MIT faculty.

2 In the Beginning, Laughter…

One morning over breakfast cereal and the Wall Street Journal (the only non-technical journal I read regularly) a front-page article about Manfred Clynes caught my eye. He was described as a brilliant inventor who, among better-known inventions that became commercially and scientifically successful, also invented a machine for measuring emotion. His "sentograph" (*sentire* is Latin for "to feel") measured slight changes in directional pressure applied to an immovable button that a person pushed. The finger push showed a characteristic pattern related to joy, sadness, anger, sex, reverence and more. This is not a list approved by mainstream emotion theorists – who don't include sex or reverence – and Manfred is far from mainstream. Among his many distinctions, Manfred was a child prodigy who later received a fan letter from Ein-

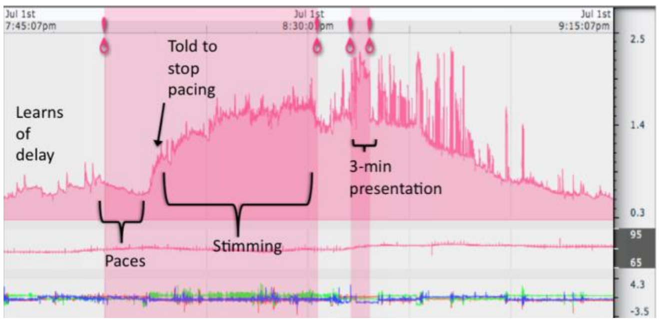

Fig. 1. Skin conductance level (top graph). Skin surface temperature (middle graph) and 3-Axis accelerometer values (lower graph). Skin conductance, which is associated with emotional arousal, was lowered during pacing, while it went up during "stimming", a presentation, and (afterward) while dealing with some audio-visual equipment problems. This data is from a young adult on the autism spectrum.

stein for his piano playing and who co-authored the 1960 paper that coined the word "Cyborg". But the Wall Street Journal described how he *measured* emotion, with objective physical signals. Later, others replicated the measures. I was amused, although not enough to do anything more than file the article, alongside other crazy ideas I liked such as refrigerators that were powered by the noise of nearby traffic. The article mentioned my friend, Marvin Minsky, who many years later introduced me to Manfred, and we became instant friends.

Manfred never claimed to be the first to build a machine to measure emotional categories. But Manfred may have been the first to get laughed at for his work making affect computable. He told me about the time when he first tried to present his ideas about measuring emotion to other scientists: The audience laughed and laughed, and it was not the kind of laughter most speakers crave to elicit. He said he was literally laughed off the stage.

2.1 Discovering real importance for emotion

When I first started thinking about emotion it was the last thing I wanted to think about. I was up for tenure at MIT, working hard raising money and conducting what people later praised as pioneering research in image and video pattern modeling. I liked my work to be rooted solidly in mathematics and machine learning. I was busy working six days and nights a week building the world's first content-based retrieval system, creating and mixing mathematical models from image compression, computer vision, texture modeling, statistical physics, machine learning, with ideas from film makers. I spent all my spare cycles advising students, building and teaching new classes, publishing, reading, reviewing, raising money, and serving on non-stop conference and lab committees. I worked hard to be taken as the serious researcher I was. I had raised over a million dollars in funding for my group's work. The last thing I wanted was to wreck it all and be associated with emotion. Emotion was associated with being irrational and unreasonable. Heck, I was a *woman* coming from engineering. I did not want to be associated with "emotional," which also was used to stereotype women, typically with a derogatory tone of voice. If anybody needed to start work in this area, it needed to be a man.

However, I kept running into engineering problems that needed … well, something I did not want to address. For example, working on computer vision I knew that we had a lot to learn from human vision. I collaborated with human vision scientists who focused on the cortex and visual perception. We labored to build computer vision systems that could see like people see, and learned to build banks of filters, for example, that could detect high-contrast oriented regions and motions in ways that seemed to be similar to stages of the human visual cortex. Much engineering, whether for vision, or earlier in my life for computer architectures, was focused on trying to replicate the amazing human cortex. We wanted to figure it out by building it. But nowhere did any of the findings about the human visual cortex address a problem I wanted to answer: How do you find what is *interesting* for a person? How do you find what *matters* to them? How do visual attention systems figure this out and shift automatically when they need to shift? Building a vision system is not just about detecting high-contrast oriented lines or telling a dog from a cat. Vision is affected by attention, and attention is affected by what matters to you. Vision, real seeing, is guided by feelings of importance.

Another problem arose from my years of work at AT&T Bell Labs and at MIT building new kinds of computer architectures for digital signal processing. We came up with many clever ways to parallelize, pipeline, optimize, and otherwise process sounds and sights and other signals humans usually interpret effortlessly. However, never did anyone figure out how to give a computer anything like motivation, drive, and a sense of how to evaluate shifting priorities in a way that acted genuinely intelligent. The machines did not genuinely *care* about anything. We could make it print, "Hello world, I care. Really,…" but we weren't fooled by that. We could give it functional programs that approximated some affective motivational components like "drive." Such programs worked under limited conditions that covered all the cases known up front – but always failed pathetically when encountering something new. And it didn't scale – the space of possibilities it needed to consider became intractable.

Today we know that biological emotion systems operate to help human beings people handle complex unpredictable inputs in real time. Today we know that emotions signal what matters, what you care about. Today we know emotion is involved in rational decision-making and action selection, and in order to behave rationally in real life you need to have a properly functioning emotion system. But at that time, this was not even on the radar. Emotion was irrational and if you wanted respect then you didn't want to be associated with emotion.

Most surprising to me was when I learned that emotion interacts deeply in the brain with perception. From human vision research on perception, we all understood perception to be driven by the cortex – the visual cortex for vision, the auditory cortex for audition, etc. But one Christmas break, while reading Richard Cytowic's "The Man who Tasted Shapes," I was jolted out of my cortex-centric focus. In synesthesia, such as when a person feels shapes in his palms when tasting soup, or sees colors with letters involuntarily or other crossed perceptual modalities, the cortex was observed to be showing less activity, not more.

Cytowic argued that multi-modal perception was not only happening in the cortex, but also in the limbic structures of the brain, regions physically below the cortex, which were known to be important for three things: attention, memory, and emotion. I was interested in attention and memory. I started to read more neuroscience literature about these limbic regions. I was not interested in emotion. Alas, I found that the third role– emotion – kept coming up as essential in perception. Emotion biased what we saw and heard. Emotion played major roles not only in perception, but also in many other aspects of intelligence that AI researchers had been trying to solve from a cortical-centric perspective. Emotion was vital in forming memory and attention and in rational decision-making. And, of course, emotion communication was vital in human-machine interaction. Emotions influence action selection, language, and whether or not you decide to double-check your mathematical derivations, comment your computer code, initiate a conversation, or read some of the stories below.

Emotion being useful and even necessary was not what I was looking for. I became uneasy. I did not want to work on or be associated with emotion, yet emotion was starting to look vital for solving the hard engineering problems we needed to solve.

I believe that a scientist has to commit to find what is true, not what is popular. I was becoming quietly convinced that engineers' dreams to build intelligent machines would never succeed without incorporating insights about emotion. I knew somebody had to educate people about the evidence I was collecting and act on it. But I did not want to risk my reputation and I was too busy. I started looking around trying to find somebody, ideally male, and already tenured, whom I could convince to develop this topic, which clearly needed more attention.

2.2 Who wants to risk ruining their reputation?

I screwed up my courage and invited Jerry Wiesner, former president of MIT and Scientific Advisor to Presidents Eisenhower, Kennedy and Johnson, to lunch. Jerry was in a suit and always seemed very serious and authoritative. Over fish and bonbons at Legal Sea Foods I filled him in on some of my work and sought his advice. I asked him what was the most important advice he had for junior faculty at MIT. I strained to hear him over the noise of that too-loud restaurant, but one line came out clear: "You should take risks! This is the time to take risks." As I walked back the one block to the lab, I took a detour and did some thinking about this. I was working in an exciting new research area at the time – content-based retrieval. I liked it and was seen as a pioneer in it. But, it was already becoming popular. I didn't think it was really risky.

The Media Lab saw me as one of their more conventional players, as "the electrical engineer." Nicholas Negroponte, architect and founding director, spoke with pride and perfect French pronunciation, of how he formed the Media Lab as a "Sah-lon de ref-oos–say." The original Salon des Refusés was an exhibition by artists of work that was rejected by the authorities in charge. Nicholas was proud of establishing a lab that would do research that others might laugh at and reject. I didn't want to be labeled as a rejected misfit, but I didn't learn he saw our faculty in this way until after I was already a member of the lab. It was freeing to hear that if I were indeed ever viewed as a misfit, it would be valued. If I chose to work on emotion, the misfit title was going to happen. Maybe it would be okay here.

One of the brilliant visionaries Nicholas had recruited to the Media Lab was Seymour Papert, mathematician and leading thinker in education and technology, who told our faculty about researchers long ago who were all focused on trying to build a better wagon. They were making the wheels stronger so they stayed round and so they didn't break or fall off as easily. They worked hard to make wagons last longer, go faster, give smoother rides, and cover more distance. Meanwhile, Seymour said that while all the researchers of that day were improving the wagon wheel, these crazy engineers – the Wright brothers – went off and invented the airplane. He said we faculty in the Media Lab should be the crazies inventing the new way to fly. My maiden name is Wright. This story was inspiring.

Convinced that emotion was important and people should pay attention to it, and that maybe my lab wouldn't mind if I detoured a few weeks to address this topic, I spent the holidays and some of the January "Independent Activities Period" and wrote a thought piece that I titled "Affective Computing" to collect my arguments. I circulated it as a tech note quietly among some open minds in the lab. A student from another group, who was more than a decade older than I, read it and showed up at my door with a stack of six psychology books on emotion. "You should read these," he said. I love how the students at MIT tell the faculty what to do. I needed to hear what he said and I read the whole stack.

I then read every book on emotion I could get from Harvard, MIT, and the local library network only to learn that psychologists had over a hundred definitions of emotion, nobody agreed on what emotion was, and almost everyone relied on questionnaires to measure emotion. As an engineer, it bugged me that psychologists and doctors relied on self-reports that they knew were unreliable and inaccurate.

I went to Jerry Kagan at the psychology department in Harvard. His office was high up in the William James building. I wanted to talk to him about my ideas how to build accurate and systematic ways to measure and characterize affective information. He had been very discouraging to one of my students earlier, and I thought it was important to understand his perspective. He gave me a hard time at first, but after we argued, in the end he was very nice and almost encouraging: He told me "You're shooting for the moon" when I proposed that my team could build wearable technology to measure and characterize aspects of emotion as it naturally occurred in daily life. I thought psychologists could benefit from the systematic approach engineers bring to hard problems.

I attended neuroscience talks and read key findings on emotion in the neuroscience literature and found their methods to be more concrete – showing evidence for precise pathways through which aspects of emotional perception and learning appeared to be happening. Neuroscience studies were compelling, especially findings like Joe LeDoux's that showed perceptual learning (e.g. a rat learning to fear a tone) without involving the usual cortical components (e.g. after the audio cortex had been removed). Antonio Damasio's book Descarte's Error was also powerful in arguing for the role of emotion in rational decision-making and behavior.

I spruced up my technical note envisioning Affective Computing as a broad area that I thought engineers, computer scientists, and many others should consider working on, and submitted it as a manifesto to a non-IEEE journal that had traditionally printed bold new ideas. It was rejected. Worse, one of the reviews indicated that the content was better suited to an "in-flight magazine." I could hear the laughter between the lines of rejection. I gave a talk on the ideas to our computer vision research group and people were unusually silent. This was what I feared.

I gave a copy of the thought piece to Andy Lippman, a tall energetic man who always has bountiful words for sharing his opinions. Usually we talked about signal processing or video processing. One day he showed up in my doorway, silent, with a peculiar look on his face, holding a document. He stabbed it with his finger, shook his head, pointed at it, shook his head some more and said nothing. This was not like him. Had he lost his voice? "Is something the matter?" I angled my head. Andy was never silent. Finally he blurted, "This is crazy! CRA-

ZY!" He looked upset. I hesitated, "Uh, crazy is, good, in the Media Lab, right?" He nodded and then he smiled like a Bostonian being asked if he'd like free ice cream with mix-ins. Then I saw the document: It was my affective computing paper. He waved it, nodded and shook his head, and left with an odd smile. I never did resubmit that tech report, but it provided the only instance where I ever saw the voluble Lippman tongue-tied.

2.3 Visionary supporters trump peer review

I am a big fan of peer review, and work hard to maintain the integrity of that process. But there are times in the life of new ideas when peer-reviewed papers don't stand a chance of getting published. Sometimes years of acclimation are needed before an idea can make it through the process, even if the work is done solidly and with the best science and engineering. I realized the early ideas on affective computing were not going to make it into print until a lot more work had been done to prove them, and I only had a year before I was up for tenure. Emotion was just not an acceptable topic. How could I get a whole set of new ideas out when the average time from submission to publication of my computer vision papers was measured in years?

Nicholas Negroponte invited me to co-author his Wired column on affective computing. We published it and got a mix of responses. The most memorable responses were letters from people who said, "You are at MIT, you *can't* know *anything* about emotion." WIRED was no substitute for peer review, but it started to get my ideas out and the ideas shook some trees.

David Stork invited me to author the chapter on Hal's emotions for the book **Hal's Legacy**, commemorating the famous computer in Stanley Kubrick and Arthur C. Clarke's film, *2001 A Space Odyssey*. All of the other chapters addressed attributes of Hal like his chess playing ability, his speech, his vision, etc, and had "the most famous person in the field" to write them. David and I joked that I was the *only* person at the time that visibly represented the field of computers and emotions, and the word "field" was used with a stretch of a smile. I still enjoyed being in the book with a lot of impressive colleagues – Ray Kurzweil, Don Norman, Daniel Dennett, and others, and it was encouraging to be grouped with so many successful scientists. However, when I had dinner with Ray Kurzweil, his wife asked me if I was the "emotion woman," which only compounded my worries. But I had started digging deeper into affective computing research and I knew the work was needed, even if it wrecked my image and my career.

The famous scientist Peter Hart, after coaxing me to ride bicycles with him up the "hill" (it felt more like a mountain) of Old La Honda on a 105 degree July day, told me he thought Affective Computing was going to become very important. He encouraged me to drop all the research I'd just raised over a million dollars in funding for (content-based retrieval) and pursue affective computing wholeheartedly. I feverishly wondered how I could ever do that. Peter hosted, in July 1995, at Ricoh Silicon Valley, what was the first presentation outside of MIT on the ideas that would become my book Affective Computing. I saw Peter as an established outside authority in Pattern Recognition, not just a Media Lab crazy type, and his encouragement enabled me to believe that a book and more serious dedicated work on affect might be worthwhile. At least he would be one respected technical researcher who wouldn't write me off.

In August 1995 I emailed the director of the Media Lab that I was changing the name of my research group at MIT to "Affective Computing." He said it was a very nice name, "gets you thinking," and "is nicely confused with *effective*." I liked how easily he supported this new direction. I liked that my crazy new work would be confused with being effective.

I was asked to fax my unpublished tech report to Arthur C. Clarke (who didn't do email). I faxed it and he mailed me a personal paper letter saying he liked it. Arthur added, "I sent your paper to Stanley – he is working on a movie about AI." I never got to meet "Stanley", but I understand he was the brilliant mind behind giving HAL emotions in the film *2001*. When I read Clarke's original screenplay, it had almost nothing on emotion in it, and Clarke's subsequent book on the story also downplayed emotion. But in the film, HAL showed more emotion than any of the human actors.

Through my Media Lab connections, I started to see that there were many mavericks who had recognized the power and importance of emotion, even though there were many more in engineering and computer science who did not think that emotion mattered. I felt encouraged to push ahead in this area, despite that I heard my technical colleagues at conferences whispering behind my back, "Did you hear what weird stuff she's working on?" and some of them blushed when I looked up at them and they realized I'd overheard. I did feel vindicated five years later at the same conference when one of them asked me if I would share my affect data with him as he was starting to do work in the field.

TV producer Graham Chedd for Scientific American Frontiers came by with one of my favorite actors, Alan Alda, and got interested in what my team was doing. Graham included our very early affective research in two of their shows. I am told that these episodes still air on very late night television where you can see Alan Alda's emotional arousal going up as he thinks about hot red peppers and going down while he thinks about Saltine crackers. I'm standing next to him pregnant with my first child, trying to look like a serious scientist while I'm clanging a bell in his ear to elicit a startle response from him. Somehow it now seems fitting for late night television.

Dan Goleman called from the New York Times during a very busy week and I asked him if we could talk at a different time. He said he was going to write about our work that week whether I would make time to speak with him or not. Later his book on Emotional Intelligence sold over 5 million copies. Putting "emotional" and "intelligence" together was a brilliant combination, originally conceived by Jack Mayer and Peter Salovey in their scholarly work under this name. While the phrase is widely accepted today, at the time it was an oxymoron. Goleman's popular writing did a lot to interest the general public in the important roles emotions play in many areas of success in life – he argued it was more important than verbal and mathematical intelligences, which of course was what AI researchers had been focused on. The topic of emotion was starting to get more respect, although for some reason it was still very hard to get computer scientists to take it seriously.

Much later, William Shatner came by my office, dragged by his ghostwriter to create a new book about the science of Star Trek and the role of emotion in their shows. It was kind of a stretch to find some science given the booming sounds in the vacuum of outer space, and more. But, I did confirm that the character of Spock had emotion. Spock was not emotionally expressive and kept emotion under control, but it was important to claim that he still had emotion, deep inside, in order for his intelligent functioning to be scientifically accurate. If he really didn't have emotion, and behaved as intelligently as he behaved, then it would have been bad science in the show. The actor Leonard Nimoy, who had played Spock, later came to MIT and hosted a big event I chaired featuring new technology measuring and communicating emotional signals. He appeared remarkably unemotional, even when he was not playing Spock. I tried to convince him that he could show emotion and still be intelligent. He still showed almost no emotion, but his presence attracted more people to come and learn about why my group was developing affective technologies.

A famous high-priced speaker's bureau invited me to join their list of speakers, offering me lots of money if I would give talks about "more broadly interesting" technology topics than affect and computing. They thought emotion was not going to be of sufficiently broad interest to their well-heeled clients. I knew at this point I was going to spend all my spare cycles trying to get high quality research done on affective computing, and trying to get more engineers and computer scientists to consider working on emotion, so I declined their offer. I started giving more talks than ever on affective computing – dozens every year, mostly with zero or low pay to academic groups to try to interest them in working on affect.

I remember one talk where the famous speech researcher Larry Rabiner came up to me afterward and asked why I was working on emotion. Larry said, "It's a very hard problem to tackle, and it just doesn't matter. Why are you wasting time on it?" I don't think he had paid much attention in my talk, or perhaps I had done a very bad job of explaining. I had always admired Larry's work and this was tough to hear, but I tried to explain why I thought it was critical in early development for learning of language. I pointed out dogs and small infants seem to respond to affect in speech. He seemed to think that was interesting. He did listen but I never heard from him again.

After another talk, I remember a world-famous MIT computer scientist coming up to me agitated, looking at my feet the whole time and complaining to me, "Why are you working on emotion? It's irrelevant!" I'm told this is how you tell if a CS professor is extroverted or introverted – if he looks at his feet, he's introverted, if he looks at yours, he's extroverted. He sounded angry that I would take emotion seriously. I tried, probably in vain, to convince him of its value, and he was soon joined by others who looked at each other's feet and changed the subject to help calm him down.

On multiple occasions, colleagues confided in me that they didn't know what emotion really was other than extreme emotions like anger. Some of them even said, "I don't have feelings and I don't believe they have a physical component you can measure." I think one of the attractions of computer science to many of them was that it was a world of logic largely devoid of emotional requirements, and they didn't want this threatened. I faced quite an uphill battle trying to convince my computer science colleagues of the value of emotion.

Through my talks to various groups, I became increasingly convinced that affective computing needed to be addressed, even if most computer scientists thought emotion was irrelevant. I wanted to make affective computing interesting and respectable so that progress would be made in advancing its science. I was always encouraged when people would go from looking scared of the topic, as if it was going to be an embarrassing talk to be seen at, to wanting to spend lots of time with me afterward talking deeply about the subject.

Somehow in the midst of all of this, while up for tenure, trying to build and move into a new house, and getting ready to give birth to my first son, I signed a book contract in 1996, moved into the house, delivered the baby, delivered the book nine months later, and submitted my tenure case to MIT with a freshly minted copy of "Affective Computing." At the time I had no peer-reviewed journal papers related to affective computing, those would come later. All my peer-reviewed scientific articles were on mathematical models for content-based retrieval or were conference papers on affective signal analysis. I was told that reviewers didn't know what to make of my schizophrenic tenure case: They wondered if the book was authored by somebody different than the person who wrote the papers, as if "Rosalind Picard" was a common name and maybe there were two of her.

Fortunately, I was in the Media Lab, probably the only place on the planet that loved you more the weirder you were. They were willing to take big risks. Jerry Wiesner's influence was huge, and our building was named after him. The director of our lab, Nicholas Negroponte phoned me one day and said, "Roz, good news. Your tenure case went through like a hot knife through butter." The risk I had taken to start out in a totally new area, one that almost nobody wanted to be associated with, had not hurt my career. But I never did it for my career, I did it because I believed then, and I still believe, that affective computing is an extremely important area of research.

I was also amazed how, over time, the appeal of the topic became very broad – not just to researchers in computer science and human computer interaction, but also in medicine, literature, psychology, philosophy, marketing, and more. Peter Weinstock, a leading physician at Boston Children's Hospital today calls emotion "the fourth vital sign." I had never known there were so many communities interested in affect and I started to engage with researchers in a huge number of fields. I have learned a ton doing this, and it has been mind expanding.

I was delighted to see workshops on Affective Computing springing up around the world, led by visionary colleagues in computer science and psychology who were also bold in taking risks. I did not help much in terms of organizing meetings and admire greatly the huge efforts put in by so many talented technical colleagues who truly fostered the growth of this field. I cannot properly name them all here; however, Klaus Scherer, Paolo Petta, Robert Trappl, Lola Canamero, Eva Hudlicka, Jean-Marc Fellous, Christine Lisetti, Fiorella de Rosis, Ana Paiva, Jianhua Tao, Juan Velasquez, and Tienu Tan played especially important and memorable roles instigating some of the early scientific gatherings. Aaron Sloman, Andrew Ortony, and I were frequent speakers at these gatherings, and I enjoyed their philosophical and cognitive perspectives and challenges.

The HUMAINE initiative became very influential in funding significant European research on emotion and computing, propelling them ahead of research efforts in the United States. The community involved a lot of top researchers under the warm leadership of Roddie Cowie, and with the expert technical support of Marc Schroeder was well organized and productive, funding dozens of groundbreaking projects.

The US did not seem as willing as Europe to take bold risks in this new research area and I always wondered why we lagged so far behind Europe in recognizing the importance of affect. I was lucky to have Media Lab corporate consortium funding with "no strings attached" or our MIT Affective Computing group would never have been able to get up and running. Meanwhile, a National Cancer Institute grant supported Stacy Marsella at USC in developing a pedagogical system to teach emotion coping strategies to mothers of pediatric cancer patients and an Army Research Institute grant recognized the importance of putting emotions into the cognitive architecture Soar (work by Paul Rosenbloom, also at USC, which not only included Jonathan Gratch, but also hooked him on emotion.)

Much later the National Science Foundation funded work by Art Graesser at Memphis that included my lab helping develop emotion recognition tools for an intelligent tutor, and then still later, work by Rana el Kaliouby and Matthew Goodwin and me building affective technology for autism. While I remain very grateful for all sources of funding, I especially am grateful for those who find ways to give scientists the freedom to try things before the ordinary peer-review and proposal-review processes are ready to accept them. Emotion did not start out with respect and if we had to wait for traditional sources of funding to get it to that point, this chapter would probably not be here.

3 …TO IEEE AND BEYOND

I have a long history with the Institute of Electrical and Electronics Engineers (IEEE) from joining as a student to decades later being honored as a Fellow. I played a small role in helping found the IEEE International Symposium on Wearable Computing and the wearables special interest group. I have served on dozens of program committees, organized workshops, and served as guest editor and associate editor of IEEE Transactions on Pattern Analysis and Machine Intelligence. I've reviewed so many IEEE papers that if combined into vertical stacks, they could bury a poor innocent bystander if they toppled. I know the high integrity and raise-the-bar standards of the IEEE research community.

However, when I submitted my first carefully written technical emotion recognition paper focusing on physiological pattern analysis to the IEEE conference on "computer vision and pattern analysis (CVPR)" the reviewers wrote "the topic does not fit into CVPR since it doesn't have any computer vision in it." Later I strategically put "Digital processing of…" and "Signal processing for…" in the titles of papers submitted to the IEEE International Conference on Acoustics, Speech, and Signal Processing and they got accepted. This same trick worked to get past the "it doesn't fit" excuses for our first IEEE Trans. Pattern Analysis and Machine Intelligence paper on affective computing as well: I put "machine intelligence" in the title. Of course it was not that easy: the editor also insisted that five thorough reviewers iterate with me before approving the paper. Usually three will suffice. I had been an associate editor of PAMI and seen a lot of reviews, but never seen any set of such length as required for this first paper on emotion. I addressed every comment and the paper got published.

By the way, it was not just the IEEE – the ACM also rejected my first affective computing submission as "not matching any of the topics or themes in the human-computer area." I wondered from the review if they had even read the paper or just rejected it when they saw it addressed emotion. Years later I was delighted when several affective topics were added to their official themes. To this day, I still feel slightly amazed when I see conferences that openly solicit affective topics even though Affective Computing has its own international conference now and many other conferences also openly solicit affective computing work. It wasn't always that way – in the beginning, emotion was really fringe, unwelcome, and the few people working on it had to have an unusually large allocation of self-confidence.

In 2010, Jonathan Gratch led our community in launching its first journal, the IEEE Transactions on Affective Computing, which truly presents the field as respectable. Jaws dropped. The presence of an IEEE journal sent a message that serious engineering researchers could work on emotion and be respected.

Whether or not Affective Computing is an area in which you conduct research, you are using emotion when you choose to read this. You are involving your emotion system when you make a decision where to spend your time – when you act on what matters most to you. Affective computing researchers have a chance to elucidate how emotion works: how to build it, how to measure it, how to help people better communicate and understand it, how to use this knowledge to engineer smarter technology and how to use it to create experiences that improve lives.

Affective computing is a powerful and deeply important area of research, full of extremely difficult technical, scientific, philosophical, and ethical challenges. I believe it contains the most complex real-time problems to be solved in human-computer interaction and in computer science models of human behavior and intelligence. At the same time, the field is not merely a subset of computer science. The complexity and challenge of giving computers real-time skills for understanding and responding intelligently to complex naturally-occurring and naturally-expressed human emotion spans many fields, including the human sciences of neuroscience, physiology, affective-cognitive science, and psychology. Affective computing is no longer a topic to be treated lightly, although laughter remains one of my favorite emotional expressions.

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Rosalind W. Picard (M'81–SM'00–F'05) received the Bachelors degree with highest honors in electrical engineering from the Georgia Institute of Technology, Atlanta, in 1984, and the S.M. and Sc.D. degrees in electrical engineering and computer science from the Massachusetts Institute of Technology (MIT), Cambridge, in 1986 and 1991, respectively. From 1984 to 1987, she was a Member of the Technical Staff at AT&T Bell Laboratories, Holmdel, NJ where she contributed to the creation of novel computer architecture for image compression. She interned at Hewlett Packard, IBM, and Scientific Atlanta and consulted at a variety of companies, including Apple, IRobot, BT, and Motorola. She is professor of media arts and sciences at the MIT Media Laboratory, where she is also the founder and director of the Affective Computing Group. She is co-founder of Affectiva, Inc., a company created to help people measure and communicate emotion. Picard has authored or coauthored more than 200 scientific articles. She is known for pioneering research in image and video content-based retrieval (the original Photobook system), for developing texture models and machine learning for their combination (Society of Models), and for her book Affective Computing (MIT Press, 1997), which envisioned and helped launch the field by that name. Her research interests include the development of technology to help people comfortably and respectfully measure and communicate affective information especially for applications related to various developmental or affective disorders.