Kinesiology Review, 2012, 1, 197-206

Kinesiology Review
Official Publication of NAK and AKA
www.KR-Journal.com
REVIEW

The Content and Context of Performance: An Autobiographical Account of Scientific Development

P.A. Hancock

What I seek to achieve in this article is an exploration of how some of the distilled and assembled principles of behavior can be applied to human goals, aspirations, and performance writ large. I look to do this through an analysis of various areas of application, although the primary framework upon which I erect this discourse is my own autobiographical progress in science. My grounding in formal research was derived from motor learning and control and it then developed into an examination of all human interaction with technical systems under the general title *human factors/ergonomics*. In showing an indissoluble link between the foundations of motor control and the technological mediation of human factors and ergonomics, I hope to inform and inspire their consideration of the greater aspirations for all of kinesiological science. In terms of specifics, I discuss the work my laboratory has produced over a number of decades on issues such as driving, flight, and other human-augmenting technologies, with a special focus on performance under stress and high workload conditions. To conclude, I discuss, dispute, and finally dispense with the proposition that science and purpose (proximal understanding and ultimate meaning) can be dissociated. I hope to demonstrate why the foregoing principles and their ubiquitous application mean that science in general bears a heavy, if unacknowledged burden with respect to the current failings, especially of Western society.

***Keywords*:** movement, meaning, morality

To a degree, every scientific work contains at least an element of the autobiographical or in Nietzsche's terms "philosophy is the biography of the philosopher." The choice of the topic, the selection of the methodology, the conclusions drawn and expressed aspirations for the future all reflect the personal persuasion of the individual author. The present work, however, is more explicitly autobiographical than most and represents a series of reflections on my own personal progress and choices across my career to date. It is my hope that these observations are useful to those contemplating their own career. Since the central theme of my own development is reasonably captured under the description of Human Factors and Ergonomics (HFE), the topics I discuss are linked but they do not represent any one specific area of investigation. Hence, the narrative which follows has both chronological and thematic threads. But before I begin on this very personal odyssey I want to make an initial observation on the role of luck in any career, as this plays a greater role than we might suspect or expect. To the degree that one achieves success; the highly seductive tendency is to attribute all of that success to one's own capacities and efforts. In this lies the heart of a very irregular verb (i.e., I worked very hard, he was lucky, etc.). However, I believe that as both a general proposition, and certainly in my own particular case, that a large degree of success is due to the good fortune of circumstance. I shall look to explain how such fortune affected me especially in terms of those who have helped and facilitated my career across the years.

Stage 1: Graduate Studies and the Importance of Feedback

Like many of those who have found their way into kinesiology, my entry began with my love for different sports. Such interests led me, after some checkered academic developments, into a path toward the teaching of physical education. In England, where I was born and grew up, the preeminent location for the study of kinesiology was at Loughborough College of Education. It was there that I began college in the fall of 1972. Like many at Loughborough, my focus was on the learning of sports but more particularly on the playing of sports. To a fair degree, the academic dimension of the program took a back seat to the activities on the sports fields, especially those of the Saturday and Sunday games. Motor control was just one of many courses, however, I do remember once playing volleyball for the Bryant J. "Jack" Cratty trophy. Cratty had been quoted so many times by our lecturer in Motor Control that one of my fellow students had written to Cratty in the U.S. The letter he wrote

The author is with the Dept. of Psychology, and The Institute for Simulation and Training, University of Central Florida, Orlando, FL.

back became the trophy for the competition; alongside tee shirts whose logo read "B.J. Cratty says . . .". Also frequently cited at that time was Bob Singer. Little did I ever suspect that one of my own children would later become Singer's academic "grandchild," but more of that later. My second year at Loughborough brought a more than salutary realization that I was good at all sports but sadly, outstanding at none. Clearly, my future did not lie in any professional sports career and had to be sought elsewhere. I had also begun to understand that although I might make a reasonably adequate instructor, I would never be as capable or inspiring as my father who was an exceptional teacher. If I were to make my own individual mark (as all aspiring professionals should), then, I would have to take a different direction. Then, one quiet Sunday afternoon, I discovered the library. It proved to be such a peaceful and relaxing haven; indeed the very antithesis of the physical challenge of the sports field that I sought repose there in many of the days which followed. Rapidly, I began to very much enjoy the process of 'research;' wild and unstructured though my efforts were at the time. I have looked upon my career since as an extension of that feeling of wonder and delight in discovery. From that time, my profession may have been demanding but it has never been 'work.' It is indeed trite but true observation that if you love what you do you will never work a day in your life. My first piece of 'sage' advice then is to ensure that you love what you do. If that is not science, leave and find what else it is.

Until that time, I had not contemplated going further in academics or even considered taking the fourth, degree year at Loughborough. However, although my studies were unguided and ill-focused and the gaps in my knowledge fearsome, the seed had been planted. I played catch-up throughout year three and then the fourth degree year also. My primary interests focused on physiology[1] and it began to dawn on me that future formal exploration might be possible. At that time, I was aware of no Loughborough student who had gone beyond the Bachelor's degree level; was it even possible? There was no model or template on how to proceed. It was then that good fortune came my way. In Loughborough parlance, I went 'up the hill' to the adjacent Loughborough University and after a number of interviews was accepted by Ernest J. Hamley on to the Master's program there in Human Biology. I began this course after a year of teaching which allowed me to build up a "war chest" of funds. However, during this period, I again had great good fortune in winning a Training of Personnel Scholarship (TOPS) which essentially paid for the whole year of study. I shall not rehearse all of the ins and outs by which I won this award. Suffice it to say it very much taught me the value of "just turning up" about which I shall have more to say in my summary. This has been an exceptionally long autobiographical introduction into what was to become my first principled research explorations.

The Loughborough Master's program required a thesis and my chosen work was on closed-loop modeling of physiological responses. In selecting this topic, I was much influenced by the conceptual thinking of Norbert Wiener (e.g., Wiener, 1950) as well as the attraction of recent advances in digital computing. To accomplish my work I taught myself FORTRAN and learned to tote around boxes of rectangular blue cards and reams of computer printout. In such times, one was not allowed to touch (or even see) the computer itself. Rather, one handed in a deck of blue programming cards through a small hatch and returned a day later to claim your output. Each syntax error cost you a day! Meanwhile, I was testing participants in an environmental chamber in thermal conditions and at levels of work that today would not get past any human-participants board, since the individuals worked essentially to exhaustion (see Figure 1).

Lest the reader think that those were intolerably frustrating conditions, let me just say that I found them exactly the opposite! Taking data, matching them to the model, then rethinking and amending the model (Stolwijk, 1971) provided not just insight but positive excitement. I took to haunting the Digital Computer Laboratory (DCL) and was regularly first in line each morning. I have never lost this sense of excitement and anticipation in the process of both data collection and model development. I now knew that I had found what I wanted to do. I had rapidly learned the vital difference between passive and active models, an insight I still use to this day (Hancock, 2012a), although 'passive' models are now relatively rare in modern science. I also had an extensive opportunity to see people actually laboring under the very extremes of environmental stress; a topic which I have followed throughout my career (Hancock & Desmond, 2001; Hancock & Szalma, 2008). Seeking to understand feedback-mediated systems became my first

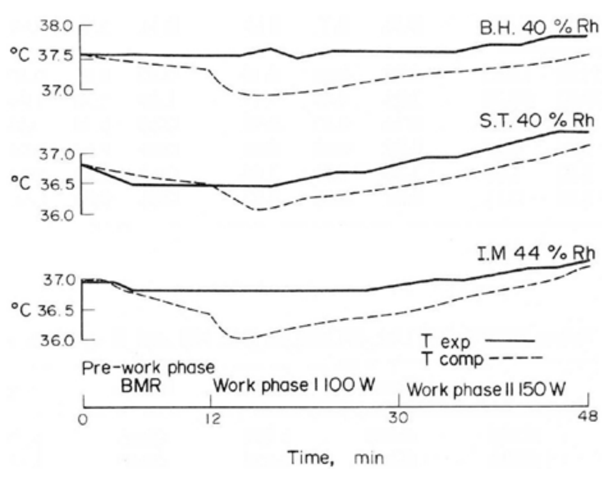

Figure 1 — Reproduced from: Hancock P.A. (1980). Simulated and experimental temperature responses in man during exercise in varying environments. *Computers in Biology and Medicine*, *10*, 1–9. Body core temperature measured rectally. Note how the computer model is not able to sustain stable body temperature through the transient phase of work onset. It graphically demonstrates what Cannon referred to as the "wisdom of the body.'

brush with "emergent properties" (see e.g., Anderson & Stein, 1987; Holland, 1998). Such emergent properties continue to fascinate and inspire to the present day. I strongly recommend finding research domains that allow you to examine phenomena at multiple levels of analysis so that such insight concerning the bloom of emergence and the constraint of convergence can be experienced in your own work. Consider as one example the following quote from Lovelock in which the whole world might be considered a feedback system:

> "Whenever an engineer . . . 'closes the loop' linking the parts of his regulator (with the rest of the system), there is no linear way to explain its working. The logic becomes circular; more importantly, the whole thing has become more than the sum of its parts. From the collection of elements now in operation a new property, self-regulation, emerges—a property shared by all living things, mechanisms like thermostats, automatic pilots, and the Earth itself." (Lovelock, 2006, p. 48)

The article that I wish had been available to me at that time was that of Iberall (1992). It would greatly have facilitated my understanding of, and subsequent transfer to, the psychological dimensions of performance which I was shortly to take up. Iberall's work remains a highly intriguing and insightful paper to this day. What I did read were two influential texts of the day on motor control (e.g., Fitts & Posner, 1967; Marteniuk, 1976). This was in preparation for my move into the unknown land of America.

Here are the lessons I learned from Loughborough:

1. Enjoy the process of pursuit and discovery in science
2. The value of the intellectual discipline associated with modeling and simulation
3. The importance of observing behavior under stress
4. The vital role and importance of feedback in systems regulation.

Stage 2: Doctoral Studies and the Profession of Science

Still anxious to pursue the path of research, I found that the opportunities to go further in England were rather limited and so following Horace Greeley's admonition to "go west young man," I looked to the United States. Again here fortune smiled on me, as I applied to only one university, somewhat on the off-chance, and that was the University of Illinois primarily because they were the only American university that even had an application form in the Loughborough University library! In the late 1970s, knowledge of the U.S. academic institutions was still very sparse in England and at the time I would not have been able to distinguish a good university from a poor one as in England most universities were of very similar standard (there being only 64 in total at the time). Again, luck exerted a significant influence—but I still had to apply. What I did not know until I arrived in Champaign-Urbana was that several Loughborough students had trodden the path before me. Professors Karl Newell, Michael Wade, and Glyn Roberts were all on the faculty at Illinois and had also previously attended Loughborough College. I was nowhere near as unique as I thought I was! I was immediately encouraged by my new advisor Karl Newell, to write-up my master's work and the series of experiments appeared in a number of papers (Hancock, 1980; 1981). In the aforementioned physiological system research, I had tested a closed-loop model against actual response (see Figure 1) and this was almost exactly the same process that was already underway in the motor learning realm. The closed-loop theory of motor learning and control naturally featured heavily at Illinois (Adams, 1971; and see also Newell, 1991). Largely by happenstance my previous work fed into my new pursuit.

At Illinois, I learned many things but, primarily, it was that of how to practice my profession as a scientist and my allegiance to theory (and see Medawar, 1979). Both were inspired and communicated by Karl Newell. Again, I had the great good fortune to work under an inspired and inspiring advisor. At that time, one had greater liberty in constructing a doctoral program than now and I well remember that Karl and I would look through the offered courses for those that seemed to represent the best the institution could offer. Thus, I took courses in psychology, physiology, and environmental engineering among others. I suspect that today a student would be much more constrained but my advice would be to seek out the best that your own institution can provide; universities remain places of great intellectual fecundity. It is up to the student to find and exploit these resources. With respect to motor control, perhaps the most interesting work that I was able to collaborate on was the space-time aspects of the speed accuracy tradeoff (Hancock & Newell 1985). It was work that had been going on immediately before I arrived at Illinois (Newell, Carlton, Carlton, & Halbert, 1980) and has been work that has continued for many years after (e.g., Newell, Carlton, & Kim, 1994). The essence of this work is epitomized in Figure 2, which illustrates what happens at extremes of motion and why such a relationship deviated from the log-linear (Fitts, 1954) and linear (Schmidt, Zelaznik, Hawkins, Frank, & Quinn, 1979) formulations which window particular segments of the overall performance spectrum. This work illustrates the importance of examining behavior at its extremes since it is under such conditions that the full portraiture of activity can be revealed. It is most gratifying to understand that this work still holds up now more than a quarter of a century later. It is a lesson to be considered that the full description of a phenomenon does not go out of fashion, even though theoretical accounts of such a description can themselves change across the years.

It was during the course of creating this synthetic work that I found myself measuring points on a specific

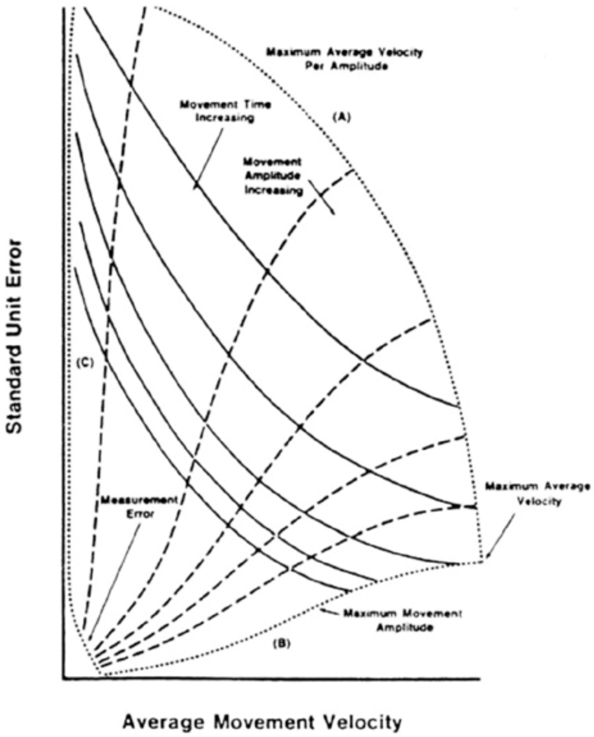

Figure 2 — Reproduced from: Hancock, P.A. & Newell, K.M. (1985). The movement speed-accuracy relationship in space-time. Invited Chapter In: H. Heuer, U. Kleinbeck, and K.H. Schmidt (Eds.). *Motor behavior: Programming, control and acquisition*. (pp. 153–188), Berlin: Springer.

graph and suddenly realized that the spatial error denoted on the axis of the graph was actually smaller than the dot on the graph itself! This caused me to ask not simply about the *measurement* of movement but the *meaning* of that movement—it is a theme I return to in my conclusion. While it is true that small levels of error can certainly matter—as any neurosurgeon knows—the impact of that error depends upon the context of performance. Sometimes small movement errors have virtually no impact at other times they portend disaster. It was this focus on context that turned me toward Human Factors and Ergonomics.

As a great university, Illinois offered a whole panacea of opportunity which, due to the latitude offered by my advisor, I was able to take advantage of. Among these was a rich spectrum of expertise in psychology and engineering psychology including a vibrant group who crossed between the two (I here take Engineering Psychology as synonymous with Human Factors). Several faculty, in particular Jack Adams, bestrode the combination of motor control and its neuropsychological and neurophysiological underpinnings and the idea of human-interaction with technology. I also sought ways of integrating the two. One such confluence concerned the effects of stress (in my early work largely thermal stress; Hancock 1982) on cognitive and psychomotor performance efficiency. At the same time, I was looking to distinguish myself from both the Illinois motor control and human factors traditions and my prior work prior (again on the principle that one has to find ways of distinguishing oneself). Yet the work had to build in some way on what I had already done (since continuity in one's record is also an important consideration). This was to be work on time perception which, having pursued in my dissertation, (Hancock, 1983) I have still continued up to the present day (Hancock, 2011). I see Illinois as the greatest stroke of fortune in my career. It was there I learned about the process of science and formed many of the perspectives and themes that I have pursued to this day. Of the things I wished I had known more of, one would have been a greater study of moral philosophy and I also wish I could have read and more fully appreciated the paper on the nature of time by Bertrand Russell (1915). Illinois prepared me thoroughly for my next career stage which was an Assistant Professorship where the theme of 'ever-westward' persisted. I would move to the University of Southern California (USC) and employment at the Institute of Safety and Systems Management (ISSM).

Here are the lessons I learned from Illinois:

1. The profession of scientist
2. The integration of Motor Control and Human Factors/Ergonomics
3. From the mechanisms of movement to the meaning of movement
4. Context dictates when millimeters matter.

Stage 3: Assistant Professorship and Work in the Real World

In August of 1983 I moved to Los Angeles and joined the Department of Safety Science and the Department of Human Factors at the Institute for Safety and Systems Management (ISSM) at the University of Southern California (USC). At first, I taught Aviation Physiology for the U.S. Air Force and continued my focus on stress and performance culminating in the Hancock and Warm (1989) theory as discussed below. As a private university, USC was different from a large land grant institution (i.e., University of Illinois) and ISSM was even further from the traditional college but most stimulating nevertheless. Like most assistant professors, I was looking to generate grant support and managed to succeed early. The strategy I used, which might be useful to young professionals was as follows. I evaluated the literature and sought to understand where the best people in my area were receiving support from. Next, I funded my own trip to attend a conference convened by that agency (NASA), since one should never fear to invest in oneself. I was able to talk over my ideas with research sponsors and the strategy worked and I was supported by NASA over the following seven year period. I have been grateful for that support but also cognizant that my own initiative was instrumental in the process. One other element that helped was that a colleague from Illinois arrived shortly after my first contact to work at the NASA location that supported me. He quickly became my grant monitor and we have remained friends and he has continued to be most supportive ever since. The importance of colleagues, even at the graduate-school level can never be overestimated.

Much of my research at USC was concerned with cognitive workload (Hancock & Meshkati, 1988) and I sought to further understand the effects of stress in this context. In so doing I generated a long love-hate relationship with the "Yerkes-Dodson Law." I shall not enter into all of the failures of this purported law of performance, neither shall I look to explain its ultimate value (but see Hancock & Ganey, 2003). Rather, the lesson here is that one cannot displace a concept or a label even in scientists' minds by merely harping on intrinsic flaws and failures. In reality, only a competing theory displaces another. As such, I have spent a number of years advocating for a more comprehensive account of stress and performance, generally termed the extended-U model of stress and performance capacity (Hancock & Warm, 1989). The model itself is illustrated in Figure 3. As a result of the implications of the model, I became progressively more interested in the 'shoulders' of the model; the transition between stability and instability. This brought me to considerations of phase transitions and nonlinear dynamics in stress responses which were then very much to the fore of more general thinking in science (and see Kauffman, 1993). It had been a topic of concern in motor control also (Kugler & Turvey, 1987) and again, the utility of having multiple areas of study which could be informed by methodologies and concepts which spanned across different domains of behavior served me very well. It is therefore, a strategy that I also advocate which is not having only one primary area of study. At least two and perhaps three prove to be very useful for cross-fertilization but also help you to avoid becoming 'stale' on any one issue. It will not have escaped the attention of some readers that there is a strong relationship between the areas of stress, motor control, and thermoregulation. This is indeed a fruitful intersection and is one reason why I have found Iberall's writings so insightful over the years (and see Iberall & McCulloch, 1969; Iberall & Schindler, 1973). In addition, one can draw a clear conceptual line of connection between the diabatic and adiabatic perspectives in motor control through those of thermoregulation in living systems to the advanced notion of stress and adaptation. The steps through Iberall to McCulloch to Weiner (one of my earlier identified influences) is also evident as an exemplar of the way people and personalities populate the lines of conceptual development in behavioral research (and assumedly in all of science).

One very practical ramification of these researches was the link to the military who were especially interested in performance under stress and it was at this juncture that I became particularly concerned with radical change in the level of task and environmental demand. Characterized as 'hours of boredom and moments of terror' the magnification of linking humans to machines has now made this 'months of monotony and milliseconds of mayhem,' it is an issue I continue to pursue (see Hancock & Krueger, 2010). I was exposed to much more in terms of safety, human factors and ergonomics at USC and particularly I became involved in accident investigation and collision prevention. I was much influenced, and was located physically in the laboratory of, Professor Harry Hurt (the world's leading researcher on motorcycle accidents). Again, the rigor of the engineering approach to energy transfer affected the way I viewed behavioral

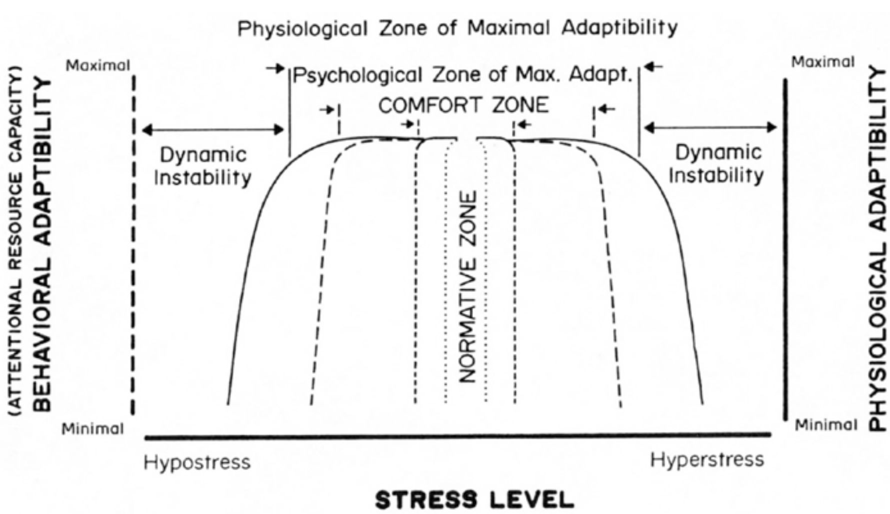

Figure 3 — Reproduced from: Hancock, P.A., & Warm, J.S. (1989). A dynamic model of stress and sustained attention. *Human Factors*, *31*, 519–537.

processes. It still remains a great point of debate the degree to which any individual is constrained by the world around them and the physical laws to which they are subject, as compared with their apparent 'freedom' of action. Of course, I very much believe that technology is the key player in this compromise between aspiration and constraint (Hancock, 2009a).

With respect to hindsight bias, the issue that I wish I had understood more at this juncture in my career was the relationship between time, causality and error (none of which I am presently convinced exist, and see McTaggart, 1908). On the advantageous side, my collaboration with Harry Hurt brought me into contact with sponsors at both the Motorcycle Safety Foundation and American Honda which were to prove most helpful in my next stage of progress.

Here are the lessons I learned from USC:

1. The practical behavioral importance of hours of boredom, moments of terror
2. Accidents and the fragility of life
3. The illusion of time
4. The value of fieldwork and real-world observations.

Stage 4: Associate Professorship and the Simulated Context of Behavior

My move to Minnesota was very much a change of climate. However, Minnesota offered me the 'no cut contract' of tenure and a number of opportunities that the sadly declining environment of ISSM within USC could not match.[II] Again, this provides an example of the importance of collegiality. The offer from Minnesota really came from Mike Wade whom I had known earlier at Illinois and it emphasizes in general just how small our communities actually are, despite the fact that motor control and human factors might appear to be very different areas. There were many attractions to the position. In the city of Minneapolis itself there were several critical locations for human factors research, such as Honeywell. Down the road in St. Paul was 3M and the Mayo Clinic was less than one hour away. However, for me the most beneficial dimension turned out to be the presence of the new Center for Transportation Studies (CTS). With my prior work on vehicle traffic accidents (e.g., Hancock, Wulf, Thom, & Fassnacht, 1990), I was again fortunate in being able to dovetail with the newly formed center and was able to secure consistent funding from CTS throughout my time at Minnesota. Such consistency was critical. More than difficult to secure today, it cannot be over-emphasized just how much consistent resources help in creating the opportunity to pursue a systematic attack on any particular issue. I chose to exploit the use of simulation to explore numerous dimensions of ground transportation and was also fortunate in being part of the nascent Intelligent Transport Systems (ITS) initiative that was then dominant in the transport world. Together with members of my laboratory, I built three full vehicle simulators, this with support from my previous contacts at American Honda. Although this led to many research projects, the one of which I am most proud was the creation and measurement of performance in an incipient collision situation. To do this, we linked two full-size simulators together so that two separate drivers drove in the same virtual world. The battles to reduce the interaction 'lag' time alone challenged several computer science students as well as the creation of the virtual driving 'world' itself. Finally, we were able to test—but how to instruct drivers so that they did not know a collision might be coming? In fact, what instructions do you actually give? I shall not give the answer away here, but did find a simple and innovative solution and the work went on to win a major international award (see Hancock & de Ridder, 2003) and help in many driving instruction courses. I remain hopeful that the insights garnered have helped save lives.

With the expertise in creating artificial performance worlds, I also obtained the first ever research grant (as opposed to contract) from the Federal Aviation Administration (FAA). This work concerned commercial pilots' self-navigation or 'free flight.' The work, later headed up in my laboratory by my Post-Doc Kip Smith, produced many worthy findings, but one I still find rather staggering. Much of the motor control community is aware of the concept of time-to-contact (see Hancock & Manser, 1997). Traditionally, this is visually specified and the contention was originally over whether it was computationally derived as opposed to a direct percept (e.g., see Gibson, 1979). Our professional pilots, in seeking to avoid collisions in their immediate airspace, saw only a representational 'radar' display of the other aircraft in their vicinity. Nevertheless, these highly experienced pilots still reacted as though there was a nominal 'time-to-contact.' Regardless of the angle of approach (e.g., head-on, in-trail, crossing, etc.), they responded and moved their own aircraft when a collision was three minutes away (see Figure 4). Further, their intercept value proved to be very close to the five mile restriction which represents the FAA limitation for an official 'near miss.' Our work has been used since to help define and design modern aircraft navigation displays (see also Smith et al., 1998). It is perhaps of passing interest that the necessity to integrate both hardware and software in simulation led me to employ an interesting individual who enjoyed research but, in general, did not like the discipline of a formal university education. Great institutions throw out these people all the time and one should embrace them under the heading that your job is to "comfort the disturbed and disturb the comfortable." That individual was Robert Stephens and during his time in my laboratory he would found "Geek Squad."

Here are the lessons I learned from Minnesota:

1. Humans and machine are self-symbiotic
2. Empiricism derives from a failure of imagination

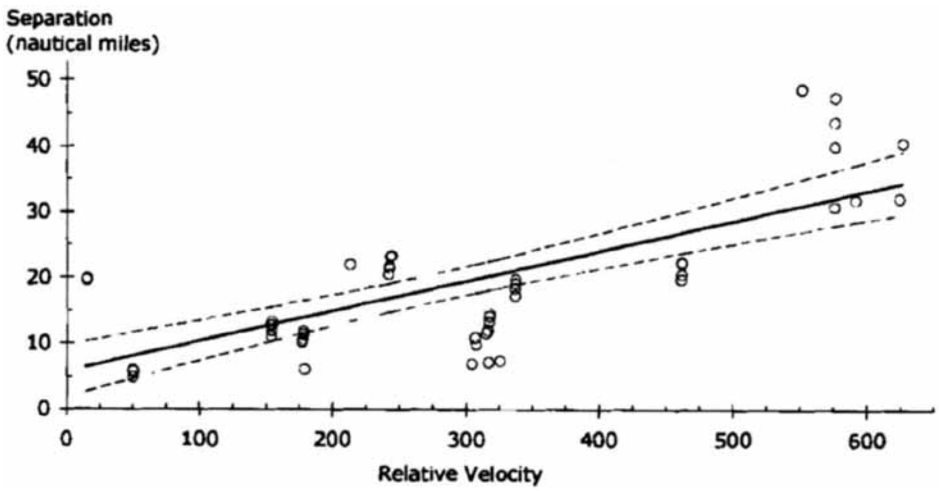

Figure 4 — Reproduced from: Hancock, P.A., & Smith, K. (2007). A distributed air traffic information display simulator: Design and results. *International Journal of Applied Aviation Studies*, *7*, 232–243.

3. Biomimetic principles are crucial for human-machine systems design
4. One's eventual legacy resides primarily in people.

Stage 5: Full Professorship and the Moral Obligation of Science

In very late 2000, I made the move to the University of Central Florida (UCF) in Orlando, Florida. Many would jest that it was the weather that attracted me, but UCF truly made me an offer as Provost Distinguished Research Professor that I could not refuse. Immediately, I became immersed in a Multiple University Research Initiative (MURI) that I had just won concerning stress, workload and fatigue in the modern military. I am proud to report it was the first behavioral MURI ever given by the US Army. Such significant support allowed me a broadening of the membership of my laboratory and also an increase in the range of methods used. The overall project ran the gamut from the laboratory cubicles, through differing levels of simulation, to field case studies (Harris, Hancock, & Harris, 2005), to full environmental mission simulations, to actual reports from conflict itself (Hancock & Szalma, 2008). Our laboratory continues with work on driving and driving simulation, especially in relation to the issue of driver distraction (see Hancock, Mouloua, & Senders, 2008; Sawyer & Hancock, 2012). Of course, this continues to feature high stress and high workload conditions and questions related to movement control and error.

Harking back to an earlier statement concerning my own offspring, I have been more than pleased to work with my daughter on a number of papers, including some in association with Chris Janelle (a graduate with Robert Singer) also concerning movement control, emotion, and driving (Hancock, Hancock, & Janelle, 2012). This has been part of an issue I shall address in my conclusion which I have labeled 'legacy.' UCF has also permitted me to explore a much larger range of topics and issues. Some of these seem 'off the beaten track' such as my recent book on history (Hancock, 2009b), as well as a more specific concern for the ethics and morality of the practice of science (Hancock, 2009a, Hancock, 2012b). Most recently, we have been working on the issue of trust, especially in relation to interactions with robots. This has led to robots being built in my laboratory and often the issue of reliability and movement control reemerges. Now we are being asked not to understand human motion but to generate and control artificial motion but the two issues are different sides of the same coin. In all, the same lessons reoccur and common themes of behavioral measurement and appropriate forms of test and evaluation persist. One's domain knowledge might vary and evolve but the issues of test, measurement and assessment continue in relevancy to all forms of behavioral science. The concern persists for issues such as individual differences, individual trials, and the challenge of nomothetic versus idiographic assessment. Can we use aggregated data to understand individual behavior and fully expose the portraiture of behavior over time (see e.g., Newell & Hancock, 1984)? Such concerns will persist long into our collective future. The answers will soon be expressed in much more dynamic and graphically interesting forms. Expect movies to replace Cartesian coordinate representations soon.

Here are the lessons I learned from Central Florida:

1. Managing small projects generates about as much work as managing large projects
2. Science bears an unpaid moral obligation
3. Formal knowability is symmetrical in space-time
4. Don't let the students have all the fun.

Summary and Conclusions

I have contended that an individual's scientific work can never be independent of their personality or the vagaries of the fortune which befalls them. I have here presented my own autobiographical progress as a way to illustrate this and also to show the especial fecundity of kinesiology as a discipline, of which I have been privileged to be a small part of. Any branch of science is composed of its living community, its historical foundations but crucially its implicit and explicit aspirations. For motor control, I argue that such aspirations should concern not simply the measurement and mechanisms of movement but also, and vitally, the meaning and ultimately the morality of that movement. This latter may, I hope, finally prove to be of preeminent concern. So, in my own work and as a general principle I think there needs to be a transition from a mechanistic to a moralistic focus for the movement sciences and perhaps all of kinesiology. This is not to abandon any of the current methodologies or hopes for understanding about the *way* people move, but it is an appeal to incorporate concern for *why* people move (the interrelationship between purpose and process). This is not a path that I can either impose or assert unequivocally as the 'right' one—it is simply the one I have chosen and the one that I champion here. While I propose, it will be left to other, necessarily, to dispose.

At the end of the present discourse, the reader is very much entitled to ask; what are the summary lessons that can be helpful in my own work? I shall now endeavor to distill these, although they naturally come with a disclaimer. The disclaimer is that these are not algorithms for achievement but rather heuristics for help, and they should be understood in this light only. First, I think it is important to be very clear in one's own mind what mountain it is one wishes to climb. This requires brutal honesty. Is it fame, fortune, knowledge, happiness, comfort or something else you seek? These aims are not mutually exclusive of course, but the way in which one frames one's activities is certainly contingent upon the value you personally place on each. Constant consideration of one's own motivations is not wasted time. My second recommendation is simpler in nature. Much of success comes down to 'just turning up' but one must not forget to turn up! It is quite remarkable how many individuals don't. Although luck does play a role, one has to be prepared to fulfill one's part in being lucky. For rising kinesiology students understand that when you feel you have mastered any particular area, that is really only the beginning. Your contributions will begin when you have reached the boundary of everyone else's ignorance. Remember that the true purpose of science is not to study the world but to change it. Don't be discouraged if the world does not immediately acclaim your wonderful thoughts. One's impact is not always easy to assess and if there is value in your insights you have to persist and keep telling your story. Use technology to your advantage in doing so. As students of kinesiology you know many of the secret well-springs of individual behavior. One can use such knowledge to one's advantage.

For those individuals further on in their career, I personally have followed three themes that might prove useful if considered.

Theme 1: Closure

It is so easy to leave open so many projects that never quite came to fruition; the student who left and never pursue publication of their dissertation into which you put so much time and effort; one's own ideas jotted down but never fully developed; but finally in terms of closure, know when you have done with a particular issue and then try to move on (sadly others will always try to pull you back to it). For a while then consider closure but always in light of the second theme.

Theme 2: Impact

Ask what difference you have made and are making. Consider the breadth versus depth trade-off in one's own writing. What is the marginal value of your next publication to the field and to the greater society? If you cannot envisage this impact then consider recasting the work and creating a larger contribution.

Theme 3: Legacy

As a senior scholar one has to ask what is it that you seek to leave? What will have been your influence? How has your published work, and the students and colleagues you have influenced, changed the course of your field? Do you see your contribution as descriptive, methodological, theoretical, or any and all combinations of these?

These are the themes that I keep before me. As I noted earlier, I believe that I do not have a profession per se. That is, I do not consider what I do to be 'work' in the accepted sense of the word. I am privileged to explore the world before me and to communicate what I have learned along the way. I hope that some of this has been helpful to you.

Acknowledgments

I would like to thank Karl Newell for his helpful comments on an earlier version of this paper and also Jane Clark for her initial encouragement to produce this work and her helpful guidance, direction, and suggestions at each stage of its development. I am grateful to the respective sources for permission to reproduce my various works.

Notes

I. At Loughborough one received a Teaching Certificate (Cert. Ed.) after three years and then those with sufficiently high marks could elect to proceed to the fourth, B.Ed., degree year.

II. For some time before I left, the upper administration at USC had decided to remove all Institutes from the University and either disband them or coalesce them under 'revenue centers' (Colleges). ISSM was the biggest and the last to fall. It provided tertiary education, distance education, and on-line education in the early eighties. Now these things are all the rage! It is one of the lessons of the academic world that all one builds up can be readily wiped out with the stroke of an unknowing and sometimes uncaring administration (see Mittler, 1991). The absence of an effective feedback loop, especially in terms of responsibility, means that such mistakes are endemic to the system.

References

Adams, J.A. (1971). A closed-loop theory of motor learning. *Journal of Motor Behavior, 3*, 111–150.

Anderson, P.W., & Stein, D.L. (1987). Broken symmetry, emergent properties, dissipative structures, life: Are they related? In F.E. Yates (Ed.), *Self-organizing systems: The emergence of order* (pp. 445–457). New York: Plenum Press.

Fitts, P.M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of Experimental Psychology, 47*, 381–391. doi:10.1037/h0055392

Fitts, P.M., & Posner, M.I. (1967). *Human performance*. Oxford, England: Brooks/Cole.

Gibson, J.J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.

Hancock, G.M., Hancock, P.A., & Janelle, C.M. (2012). The impact of emotions and predominant emotion regulation technique on driving performance. *Work: Journal of Prevention, Assessment, and Rehabilitation, 41,* 5882–5885.

Hancock, P.A. (1980). Simulated and experimental temperature responses in man during exercise in varying environments. *Computers in Biology and Medicine, 10,* 1–9. doi:10.1016/0010-4825(80)90002-5

Hancock, P.A. (1981). The simulation of human core temperature. *International Journal of Bio-Medical Computing, 12,* 59–66. doi:10.1016/0020-7101(81)90025-8

Hancock, P.A. (1982). Task categorization and the limits of human performance in extreme heat. *Aviation, Space, and Environmental Medicine, 53,* 778–784.

Hancock, P.A. (1983). The effect of an induced selective increase in head temperature upon performance of a simple mental task. *Human Factors, 25*, 441–448.

Hancock, P.A. (2009a). *Mind, machine, and morality*. Chichester: Ashgate.

Hancock, P.A. (2009b). *Richard III and the Murder in the Tower*. England: The History Press.

Hancock, P.A. (2011). On the left hand of time. *The American Journal of Psychology, 124*, 177–188. doi:10.5406/amerjpsyc.124.2.0177

Hancock, P.A. (2012a). Ergaianomics: The moral obligation and global application of our science. *The Ergonomist, 503,* 12–14.

Hancock, P.A. (2012b). Notre trahison des clercs: Implicit aspiration, explicit exploitation. In R.W. Proctor & E.J. Capaldi (Eds.), *Psychology of science: Implicit and explicit reasoning* (pp. 479–495). New York: Oxford University Press.

Hancock, P.A., & de Ridder, S. (2003). Behavioral response in accident-likely situations. *Ergonomics, 46*, 1111–1135. doi:10.1080/0014013031000136386

Hancock, P.A., & Desmond, P.A. (Eds.). (2001). *Stress, workload and fatigue*. Mahwah, NJ: Lawrence Erlbaum.

Hancock, P.A., & Ganey, H.C.N. (2003). From the inverted-U to the extended-U: The evolution of a law of psychology. *Journal of Human Performance in Extreme Environments, 7*, 5–14.

Hancock, P.A., & Krueger, G.P. (2010). *Hours of boredom—moments of terror: Temporal desynchrony in military and security force operations*. Center for Technology and National Security Policy: Defense and Technology Paper. http://www.ndu.edu/ctnsp/publications.html

Hancock, P.A., & Manser, M.P. (1997). Time-to-contact: More than tau alone. *Ecological Psychology, 9*, 265–297. doi:10.1207/s15326969eco0904_2

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

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

Hancock, P.A., & Newell, K.M. (1985). The movement speed-accuracy relationship in space-time. In: H. Heuer, U. Kleinbeck, and K.H. Schmidt (Eds.). *Motor behavior: Programming, control and acquisition*. (pp. 153–188), Berlin: Springer.

Hancock, P.A., & Szalma, J.L. (Eds.). (2008). *Performance under stress*. Aldershot, England: Ashgate Publishing.

Hancock, P.A., & Warm, J.S. (1989). A dynamic model of stress and sustained attention. *Human Factors, 31,* 519–537.

Hancock, P.A., Wulf, G., Thom, D., & Fassnacht, P. (1990). Driver workload during differing driving maneuvers. *Accident; Analysis and Prevention, 22*, 281–290. doi:10.1016/0001-4575(90)90019-H

Harris, W.C., Hancock, P.A., & Harris, S.C. (2005). Information processing changes following extended stress. *Military Psychology, 17*, 115–128. doi:10.1207/s15327876mp1702_4

Holland, J.H. (1998). *Emergence: From chaos to order*. Oxford: Oxford University Press.

Iberall, A., & McCulloch, W. (1969). The organizing principle of living systems. *Transactions, American Society of Mechanical Engineers, Series D. Journal of Basic Engineering, 91,* 290–294. doi:10.1115/1.3571099

Iberall, A., & Schindler, A. (1973). On the physical basis of a theory of human thermoregulations. *Transactions, American Society of Mechanical Engineers, Series G. Journal of Dynamic Systems, Measurement, and Control, 95,* 68–75. doi:10.1115/1.3426652

Iberall, A.S. (1992). Does intention have a characteristic fast time scale? *Ecological Psychology, 4,* 39–61. doi:10.1080/10407413.1992.10530792

Kauffman, S.A. (1993). *The origins of order*. Oxford: Oxford University Press.

Kugler, P.N., & Turvey, M.T. (1987). *Information, natural law, and the self-assembly of rhythmic movement*. New Jersey: Lawrence Erlbaum.

Lovelock, J. (2006). *The revenge of Gaia*. London: Penguin.

Marteniuk, R.G. (1976). *Information processing in motor skills*. New York: Holt, Reinhart, and Winston.

McTaggart, J.E. (1908). The unreality of time. *Mind, 68,* 457–474. doi:10.1093/mind/XVII.4.457

Medawar, P. (1979). *Advice to a young scientist*. New York: Basic Books.

Mittler, E. (1991). Survival in the face of success: The case of the Institute of Safety and Systems Management at the University of Southern California. *International Journal of General Systems, 19*(1), 11–24. doi:10.1080/03081079108935159

Newell, K.M. (1991). Motor skill acquisition. *Annual Review of Psychology, 42,* 213–237. doi:10.1146/annurev.ps.42.020191.001241

Newell, K.M., Carlton, M.J., Carlton, L.G., & Halbert, J.A. (1980). Velocity as a factor in movement timing. *Journal of Motor Behavior, 12,* 47–56.

Newell, K.M., Carlton, L.G., & Kim, S. (1994). Time and space-time movement accuracy. *Human Performance, 7*, 1–21. doi:10.1207/s15327043hup0701_1

Newell, K.M., & Hancock, P.A. (1984). Forgotten moments: Skewness and kurtosis are influential factors in inferences extrapolated from response distributions. *Journal of Motor Behavior, 16*, 320–335.

Russell, B. (1915). On the experience of time. *The Monist, 25*, 212–233.

Sawyer, B.D., & Hancock, P.A. (2012). Assisted entry mitigates text messaging-based driving detriment. *Work: Journal of Prevention, Assessment, and Rehabilitation, 41,* 4279–4282.

Schmidt, R.A., Zelaznik, H., Hawkins, B., Frank, J.S., & Quinn, J.T. (1979). Motor-output variability: A theory for the accuracy of rapid motor acts. *Psychological Review, 86*, 415–451. doi:10.1037/0033-295X.86.5.415

Smith, K., Scallen, S.F., Knecht, W., & Hancock, P.A. (1998). An index of dynamic density. *Human Factors, 40*, 69–78. doi:10.1518/001872098779480604

Stolwijk, J.A.J. (1971). *A mathematical model of physiological temperature regulation. NASA CR-1855*. Springfield, VA: National technical Information Service.

Wiener, N. (1950). *The human use of human beings*. Cambridge, MA: De Capo Press.