

Skill: making, cognition, neuroscience.

Or possibly ***Skill: knowledge and the body***, Or ***Skill: intelligence in action***, Or ***Skill: knowledge, embodiment, neuroscience***, Or ***Skill - towards a nondualist neurophysiology***

Blurb: This book challenges the conventional dualistic binary skill vs intelligence. It seeks to revalorize skill qua cognition. A philosophical historiography reveals the culturally contingent and historically constructed nature of conventional philosophical concepts that bear on the subject – primarily notions of mind, consciousness, and mental capacities. Acknowledging the slippage from mind/body to brain/body dualism, I pursue a reconceptualisation of neurophysiology that is holistic and non-dualist. A new approach to embodied skilled practices is then formulated, rooted in a non-dualist approach to neurophysiology - that necessarily reconfigures concepts of skill, intelligence and cognition. On the basis of this, (cognitive) qualities of situated skilled practices are explored, delving into specialised topics and case studies. This leads into a discussion of pedagogies for skilled practices and the place of skilled practices in broader pedagogical contexts. This in turn leads into discussions of work and learning in digital environments.

Scenario

The first born-digital generation are having kids. In their lifetimes, diverse work and leisure practices have been substituted by screen-based practices. This transition involves a reduction of what we might call 'cognitive diversity', in the sense that different kinds of practices that involved diverse techniques, instruments, tools and materials have been replaced by screen-pointer-keyboard activities. Traditionally: writing, painting, photography, mathematics, engineering design, speaking to remote relatives, keeping our calendars and playing games involved specific paraphernalia and materials, and complementary highly attuned skills – without which the paraphernalia was useless. Today we do all these on-screen, using qwerty keystrokes. Does this matter? In part as a result of rhetorics surrounding computing, the internet, social media and AI, we have come to believe that we live in a 'knowledge economy', and that access to information (as provided to us in mostly alphanumeric form, via the internet), is of surpassing importance.

The resurgence of interest in skilled embodied practices seems to proclaim something different. As a diversity of traditional materially-specific practices are subsumed into the digital, we see growing interest in practices that exceed the embrace of the digital: cooking, gardening, carpentry, mountain-biking, rock-climbing and other sports, martial arts, yoga, and body therapies, learning and playing musical instruments, arts, crafts and artisanal practices, home renovation and backyard handywork, building dry-stone walls, participation in repair cafés and

maker-spaces - embodied skilled practices of all sorts. These activities are generally admired, regarded as personally and socially fulfilling. The acquisition of skills and competences are felt to be rewarding and valuable.

Yet the kinds of 'knowledge' or 'intelligence' that are achieved and expressed in these practices and valued by practitioners, find a declining place in the academy, and minimal acknowledgement or theoretical explication. Chemistry, biology and electronics labs, wood-shops, machine shops, kitchens, sewing rooms and art studios are disappearing from colleges and schools, and hands-on experience is seen as increasingly irrelevant to 'education' (though recent upsurge in 'active learning' and 'embodied pedagogy' testify to a growing awareness of these issues.¹ In the social sphere, interaction and entertainment increasingly takes place via the small screen, with, ironically, concomitant increase in alienation and depression (the pandemic brought many of these issues into sharp focus) as well as documented reduction of attention span.²

Does this matter? From a perspective that argues that the idea-content is what is important and the rest is implementation-details, it doesn't. But what if that perspective is wrong? What if *the way* you push the needle into the leather, or mix the mortar, or change your center of balance as you kick the ball obliquely; is both meaningful in itself, and a wellspring of cognitive resources? Not only contributing to the building of artisanal capabilities, but a groundswell for the generation of generalized concepts that scaffold language and our ability to entertain complex thought (that is, what we call intelligence)? (cf Gallese & Lakoff). A senior cancer researcher was annoyed by the removal of microbiology wet-lab from the curriculum of her oncology grad-students. I asked what it was she felt was the importance of wet-lab, expecting her to say something about lab procedures, handling chemicals and cultures, and so on. She said 'the students who don't do wet-lab are not good at formulating hypotheses'.³ The profundity of this remark cannot be underestimated.

Central to the inquiry pursued in this book is the question of the place and value of practical capability, especially in contexts where abstract or intellectual knowledge is valorised. How can we resolve this tension in the way we understand intelligent human activities and human capability? I argue that this reflects a current skirmish in a long battle regarding the privileging of abstract knowledge and the concomitant denigration of skilled practices, that are grounded in Enlightenment Humanist constructions that, on inspection, seem obfuscating at best. Drawing on diverse disciplines, this book examines historical, scientific and philosophical

¹ Cf the work of Dor Abrahamson's group at Berkeley School of Education.

² Cf the work of Gloria Mark.

³ Marian Waterman. Personal communication 2023.

dimensions of this rift, and attempts to build a more coherent picture of embodied skilled practices as central to what we call intelligence.

The project

This book is about *skill* – even in Shakespeare’s day ridiculed as the province of ‘*rude mechanicals*’(in *A midsummer’s night’s dream*). The battle between *theoretical* and *practical* knowledge raged during the scientific revolution (Pamela Smith, Steve Schapin) where the differences fell along class lines. In the Anglo-American orbit, the distinction continues to this day in the separation of the academy from the polytechnic (with pedagogies of artisanal practices persisting largely in amateur/apprenticeship mode). Not so much in other cultures, from the German (industrial) tradition of technical schools to the Japanese reverence for skilled artisanal practices. So why is this rift so strong on Anglo-American circles? The axiomatic assumption of mind-body dualism that is central to Judeo-Christian ideas as formalized during the Enlightenment has adhered tenaciously in the Anglo-American sphere.

Skill asks the question: *Is the conventional distinction between skill and intelligence principled and explanatorily useful (or is it a redundant philosophical construct)?* The distinction between skill and intelligence is often unclear, sometimes incoherent. Why is it important to dismantle the skill/intelligence binary? Because it is illusory and because abandoning it will permit us to comprehend cognition and intelligence better – as integrated in bodily capabilities and experience.

My goal here is to say something substantive and rigorous about skill, qua intelligence, cognition. *Skill* attempts - by critiquing conventional conceptions of skill, and integrating contemporary scholarly and scientific perspectives with ethnographic and autoethnographic reports on practice - to provide a cognitively, neurophysiologically and phylogenetically more complete picture of skill as *intelligent action in the world*. Armed with this reconfiguration of perspectives we can examine skilled practices anew, building a new conception of intelligence as enacted, as performed; and view the cognising person in a new light.

In the first part of this inquiry (section1), I undertake a critical review of relevant aspects of Western Enlightenment humanist philosophy (informed by Gilbert Ryle, Richard Rorty, John Haugeland and others). Finding this philosophical tradition wanting, I then proceed to build an alternative view, informed by diverse neuroscience-related research (section 2). My critique of dualism draws me to propose a non-dualist approach to neurophysiology – this theorisation becomes the basis for a new theory of skill. Armed with this grounding, and paradigms of

situated, distributed, enactive and embodied cognition, I reconsider skilled practices in section 3. I then reflect on digital cultures and pedagogy in sections 4 and 5).

Skill is an integrative, interdisciplinary exploration of the cognitive dimensions of a broad range of embodied skilled practices, focusing on capabilities that involve the training and refinement of multimodal sensorimotor capacities, the use of tools, instruments, and spaces that are structured to support (pragmatically and cognitively) such specialised practices. I include among 'embodied skilled practices': precision machine operation, clinical diagnosis, laboratory experimental practice, culturally valorised skills in arts, crafts and music, as well as sports and exercise activities from judo to rock-climbing. I argue for the cognitive richness of such practices, and reject the tacit principle that activities are less 'intelligent' to the extent they are 'embodied'. These conclusions have direct implications upon matters of cognitive development, psycho-physical health, pedagogy (of all kinds), and they provide valuable perspectives in the study of digital cultural practices.

Autobiographical

It is important to emphasise that the theoretical questions explored here are grounded in, and arise from, a lifetime of making practice. The author is a sculptor, sailor, boatbuilder, metalworker (blacksmithing, welding and precision machining), roboticist and gardener, as well as a teacher and theorist in the arts and digital cultures.⁴ The foundations of the current inquiry began, I now understand, in my attempts to develop custom computational-interactive technologies for immersive artworks, that traded in the sensorimotor immediacy of embodied experience (as opposed to alphanumeric screen-keyboard exchanges).⁵ I began this project to serve the needs of the inquiring practitioner. As the project has developed, I understand this inquiry as relevant to researchers in philosophy, psychology, anthropology, cognitive science, neuroscience, education, human computer interaction, and related fields.

Skill and 'the mind'

In order to develop a deeper comprehension of *skill as cognition*, one must begin with a denaturalization of entrenched values. Central to this enterprise is a recognition that conventional philosophical formulations of our lived being as divided into two parts (the

⁴ Although my background is in the plastic arts, I do not foreground questions of 'art' as it is discussed in contemporary art theory, nor the conflicted territory of 'creativity'.

⁵ See for instance <https://simonpenny.net/works/petitmal.html>, <https://simonpenny.net/works/fugitive2.html>, <https://simonpenny.net/works/traces.html>

Cartesian mind-body dualism) stand in the way of a better understanding of skilled practices. Indeed, the skill/intelligence binary is just a fractal scion of that mother-of-all-dualisms. Such binaries almost always erect obstacles to clearer understanding by proscribing acceptable explanations. They often also imply dubious hierarchies: what makes higher cognition ‘higher’?

The idea of ‘the mind’, and the status accorded to it, is one of the central motifs of Enlightenment humanist philosophy. This is a symptom of the way the person, in philosophy, is carved into thinking parts and doing parts. A commonly-accepted corollary is that mental activity -premeditation, ‘planning’, necessarily precede skilled practices (understood as mechanical procedures (Ingold calls this Hylomorphism). But first-person experience contradicts this formulation. As Gilbert Ryle says “*When I do something intelligently, i.e. thinking what I am doing, I am doing one thing and not two. My performance has a special procedure or manner, not special antecedents.*” (Ryle, 1948)*. When we enact skilled practices, the experience feels like ‘intelligent doing’. This, in daily life, is intelligence at work.

The skill/intelligence binary exists because skill – in the sense of dexterous manipulations of matter, artifacts and tools – is, in a dualist system ‘of the body’, while reasoning on mental representations is ‘of the mind’. Richard Rorty observed “*our so-called intuition about what is mental may be merely our readiness to fall in with a specifically philosophical language-game*”. (Rorty, *PMN 1979, p. 22*)* If we dispense with the concept of mind (at least as some kind of immaterial complement to the body) then the distinction between skill and intelligence is far less clear, and things get more interesting. The question ‘is it mental or physical?’ becomes nonsensical, incoherent. Addressing the matter of skill unhobbled by such constructions, one can begin to build a non-dualist understanding of skill. For instance, the traditional explanations of question ‘where do the concepts we think with come from?’ have magical or mystical qualities: Platonic ideals descending and becoming enmired in materiality, ‘ideas’ passed down from higher centers to be impregnated into dumb meat, like the annunciation. But Gallese and Lakoff (2005) argue they are derived from lived experience (see ETMs, below).

Cognitivism, embodiment and AI

Since the mid C20th, internalist, mentalist conceptions of cognition became more ‘calculatory’ with the exploitation of computational metaphors (brain is computer, thinking involves algorithms, the brain ‘processes information’ and so on). This approach is referred to as *cognitivism*, or *computationalism*. The immediate entailment being that cognition is *abstract*, operating on symbols (thus precluding any role for embodied engagement). Computationalism, even as it seemed grounded in technological analogies, smuggled-in a neo-Cartesian conception of cognition as being inherently immaterial.

If my argument is valid, and there is no principled distinction between intelligence and skill, then intelligence/skill is of the whole organism, integrated by tight feedback loops in the specificities of particular material and social contexts. Intelligence can no longer be regarded as being exclusively of or in some space of mental abstractions. To the extent that computational discourses are premised upon the separation of information and matter (software and hardware) - exposing the Cartesian roots of the enterprise - this provides an insurmountable counter-argument to (rhetorics of) artificial intelligence (AI).

A phylogenetic thesis

If we set out with the understanding that the cognitive capabilities of the person are capabilities of the biological organism as a whole, there are developmental and evolutionary arguments. Each body grew from a single cell, all parts are made of the same stuff and all functions and capacities are inherently integrated. The form and capabilities of the resulting organism are a result of evolution. These forms and capabilities evolved to further the organism's 'getting by the world'. Evolutionarily, the first neural structures occurred in the gut of sedentary animals, to facilitate digestion. As animals became mobile, the need to sense, and sense at a distance, brought forth new sensory neurology, integrated with motor neural functions: the evolutionary development of embodied capability. Neural capacities generally, support successful action-in-the-world. Brains exist to facilitate mobile organisms as they make their way in their worlds (and their 'worlds' are isomorphic with their sensory (and sensorimotor) capacities, as Jakob von Uexküll showed).

Reading philosophy of mind, one could be excused for thinking the brain grew a body. The opposite is of course the case. The successful getting-by-in-the-world (that we call skill) is, therefore, *what intelligence is for*. If bodies grew brains to facilitate success in the world, then *skill* is the central purpose and realisation of intelligence – and not some inconvenient but pragmatic ancillary to the main functions of the brain. This perspective inverts the conventional hierarchy of skill and intelligence, which privileges abstraction. By this logic, adepts in dance, bricklayers, gardeners, artisans and performers of all kinds, exhibit the epitome of intelligence. The decorations of the mental – language, music, logic, mathematics and so on – are epiphenomena.

Towards a non-dualist neurophysiology of intelligent action in the world

A corollary of the phylogenetic argument is an embracing of a holistic, non-dualist approach to neurophysiology, where cognition is a property of the whole organism, not ghettoised in the cranium. As Francisco Varela put it - *The mind cannot be separated from the entire*

organism...the organism as a meshwork of entirely co-determining elements makes it so that our minds are literally inseparable, not only from the external environment, but also from what Claude Bernard already called the milieu intérieur, the fact that we have not only a brain but an entire body. (Varela, 1999)*. A coherent conception of the cognitive qualities of skill must, in my assessment, begin by approaching skill (and cognition and intelligence) as whole-organism phenomena. I believe that insight into the nature of cognition will come from regarding the entire organism as a coherent, resonant, ringing whole. This simple fact is revealed in developmental embryology - as Kelso and Tuller put it “...if there is a lesson to be learned from the field of neuroembryology, it is that motility precedes reactivity; there is a chronological primacy of the motor over the sensory. ...any distinction between sensory and motor is an artificial one.”⁶

I argue that the complex phenomena we call cognition or intelligence must be considered properties of the whole organism, not of specific parts. The approach pursued here, informed by evolutionary and developmental neurophysiology, insists on *organismic holism*. This reconfigures conceptions of knowledge, selfhood, awareness and capability. Such holism is fundamentally incompatible with scientific research agendas premised on reductionism. This has been a dilemma in philosophy of science since the dynamical system theory, complexity and emergence became topical in the late 80s and early 90s. In such a holistic spirit, enactivists insist on the concept of the *sensorimotor*: that the conventional serial separation of sensing, cogitation and action is false (worth noting how similar this is to input-processing-output in computing - von Neumann architecture). Action is not preceded by sensing (and cogitation), sensing and acting are concurrent, we act in order to sense, sensing is integral to action.

Reductionism and holism

The principle of organismic holism presents challenges with respect to styles of research and reasoning rooted in conventional reductionist scientific methods. This is hardly news, the challenges of complex systems, dynamical systems ('chaos') theory and emergentism were grappled with in the 1990s. (Margolis, Fox Keller, Kelso, Casti, Kauffman, etc). Their effect was disruptive enough to be considered a *paradigm* shift (Kuhn). Nonetheless, many avenues of research (in cognitive neuroscience as elsewhere) have proceeded as if this did not happen. To the extent that we are composed, biologically, of entangled and interconnected networks of networks, any attempt to assign capabilities exclusively to one organ or area must always be critically scrutinized. That is not to say that specialised functions cannot be identified – we are not an undifferentiated mass of ectoplasm - the heart pumps blood and the visual cortex

⁶ (A dynamic basis for action systems. p321 Handbook of Cognitive Neuroscience. Plenum 1984 Ch 16. pp321-356).

processes visual stimuli. But assumptions that these occur in isolation are always dubious – even if disciplinary rhetorics make such claims.

Specialisation affords greater understanding of the specificities of particular mechanisms, and experimental procedures have developed around (and justify) this. But the worry about whether the whole can be understood as the sum of its parts, persists. Ulrich Neisser raised this issue in questioning the ‘ecological validity’ of ‘white box’ laboratory experiments. Analytic distinctions can be useful, but we must be vigilant if/when analytic distinctions are taken to be functional distinctions. This important caution was recognized in second order cybernetics (and in autopoietic biology). As Heinrich von Foerster famously said: *Objectivity is a subject's delusion that observing can be done without him.*

Skill in neuroscience and the social sciences

Much writing on skill in philosophy, anthropology, and sociology (Marcel Mauss, Gregory Bateson, Pierre Bourdieu, Timothy Ingold, etc.) focuses on the capable person in a social milieu, taking a descriptive, external view, speaking of skills being acquired, developed, passed on; occurring in peripersonal and intercorporeal space; or in a hybrid space of artifacts, environments and agents – as informed by *actor-network theory*, *distributed cognition*, and *cognitive ecologies*. In these approaches, questions of what, in an embodied neurocognitive sense, is involved in developing or enacting a skill, are usually elided. Much philosophy and social science (alarmingly) adheres to an anachronistic notion of the ‘five classical senses’, and seldom acknowledges the importance of proprioception and interoception, both physiologically and cognitively.

Neuroscience, on the other hand, usually centers at molecular and cellular levels. In discussions of skill, there is a yawning discursive/explanatory gap between the cellular and the social. Attempts to bridge these realms from the humanities side are few (Maurice Merleau-Ponty and Oliver Sacks come to mind). Studies in the neuroscience of tool-use, (in typically reductionist style) tend to generalize and simplify ‘tool use’ to generate viable laboratory experiments. Only a small minority in the neuroscience community address behavioural issues (notably the school of Rizzolatti, Gallese, et al in Parma). Emerging fields of social- and ‘network’ neuroscience attempt to bridge this gap by addressing the attunement and education of proprioception as fundamental to the attainment of skill.

Grounding a non-dualist conception of skill in neuroscience is not simply an attempt to muster scientific justifications, but to draw upon diverse research in order to provide an enriched understanding skilled practices, that sidesteps some of the errors of faculty psychology and

traditional philosophy of mind. But neuroscience research sometimes falls into a property-dualist trap, wittingly or unwittingly, covertly or tacitly, replacing mind-body dualism with brain-body dualism: replacing mind with brain while preserving an hierarchical binary with body. This calls for a reflexive interrogation of axiomatic assumptions (that Philip Agre called *critical technical practice*).

Interdisciplinarity

This book attempts to integrate perspectives of different academic disciplines, but to merge those with perspectives from inherently non-academic practices that are focused not on the production of texts *about*, but on the process of (often non-verbal) realisation in, and of, the world. The result is not just a theorization of skill based in a rejection of axioms of Enlightenment humanism, but one that is both grounded in a radical proposal for a neurophysiological organismic holism, and also grounded in a reporting about the experience of skilled practices - that (hopefully) practitioners will identify with.

I am, by proclivity, qualification and professional career, a maker. My degrees are in sculpture. A lifetime of tool-use, working of diverse materials and realization of ambitious projects, such work grants me a visceral familiarity with skilled practices. I want to ground this conversation in a discussion of (the experience of) skilled practice(s) – apparently anathema in some disciplines, particularly certain branches of philosophy.

The interdisciplinarity of this project exposes tensions between the ‘big-picture’, and disciplinary specialization (that can result in intellectual tunnel vision). The prospect of accusations of dilettantism is chastening. I endeavor to pursue this task with intellectual rigor with respect to the discourses of the various disciplines I draw upon. There is some ontological tension in this exercise – I feel myself butting up against a dualism/dualizing I want to reject. Inherent in this pursuit is a double reflexivity, because in writing about skill, I grapple with the seeming ineffability of writing about practice, but pursue the topic, taking cues from Ryle, Polanyi, Pickering, Ingold and others who have ventured into this territory before me.

Denaturalisation and benevolent skepticism

The attitude of this book is ‘benevolently skeptical’. In the most constructive way, it seeks to be disruptive, and syncretic. It intends to challenge orthodoxies and tip sacred cows, to open doors rather than close them.⁷ In the process of research for this book, I have come to question some

⁷ I am always willing to reconsider: as Tom Jennings wisely quipped “I’ll believe anything given enough evidence”.

precepts of conventional western philosophy, particularly around concepts of the mind and the mental, imaginary mental architectures and what I refer to as 'brain chauvinism'. As a result I shy away from deploying terminology with substantial (usually philosophical) baggage - mind, mental, consciousness, representation being typical examples. I think this can result in affirmative 'nodding', as if such terms had explanatory power.⁸ The organismically holistic approach I argue for have resulted my holding some positions that ought be stated explicitly.

Mental hierarchy skepticism. I don't believe in higher and lower cognition - or at least, I don't believe that what we call 'higher' and 'lower' comprise a hierarchy of brain processes.

Consistent with contemporary neuroscience (and contra traditional *faculty psychology*), the idea that aspects of cognition map on to different neighborhoods of cranial real-estate or brain-organs (in the sense that higher cognition is over there and motor control is here) is dubious at best. The contemporary evidence is that things are much more mixed, in ways that reflect evolution and neuroplasticity, not philosophical categories. The hippocampus, for instance, is involved in spatial orientation, verbal memory, and management of emotions like fear and anger.

Mental representation skepticism. I do not dispute that it is possible to think of things, to hear one's inner voice, or to recall images 'in the mind's eye' - though aphantasia and hyperphantasia demonstrate that people have these capabilities in varying in various sensory (or sensorimotor) modalities. But I don't believe that mental-representational schemes are needed to (for instance) control motor schemes. Part of the problem is that the term 'mental representation' (and terms like it) reside in a discursive muddle created by the confluence of different traditions. On one hand we have philosophical traditions (philosophy of mind in particular) that entail constructions like the Cartesian theatre of the mind, where a cogitating homunculus sits watching representations of the world flicker on the screen.⁹ On the other hand, neuroscientists use the label 'representation' to describe schemes of structure and at the neural level – action potentials and neurotransmitters. Rodney Brooks noted long ago, that in the AI community of the late 1980s, everyone spoke about 'planning' as if the concept was clearly defined, but, he pointed out, if you asked individual researchers what they meant by the term, they all meant different things. Similarly, in neurophilosophy, and philosophy of cognition, mental representation means many things to the extent that the term is stretched into something without clear dimensions or extent.

Brain/body skepticism. In neuroscience, brain/body hierarchy and 'property dualism' often stand-in for Cartesian substance dualism. The multifarious integration of the organism seems

⁸ I think this is why Heidegger – to the annoyance of many – insisted in sidestepping such language.

⁹ Berkeley's contortions of solipsism (*esse est percipi* - to be is to be perceived) insists that we do not, in fact, experience the world, but only mental representations of it, seem absurd. I sympathise with Dr Johnson's stone-kicking refutation. (Of course, the stone itself could not be present in Johnson's brain, but arguably the pain, or some indication of it, was. Call me a naïve realist, I believe that the world exists).

often disregarded in discipline-based studies. *'I am a neuroscientist - I study the brain'* said one neuroscientist to me, as if this was sufficient. Disciplinary separations, we must remember, are historically and culturally contingent constructions. Importantly, much innovative research occurs at the intersections of disciplines, or in the no-man's lands beyond the disciplinary walls. Building a non-dualist framework for a holistic neuroscience is therefore key.

Book Structure

Section 1 surveys terms, concepts and frameworks in conventional philosophy of mind that have become fixtures in popular cognitive discourses (within which we are accustomed to speak of skill). This necessitates a critical primer on enlightenment dualism, and an examination of the contingent cultural and historical forces that have led to notions of *mind* as we (modern westerners) understand it - especially in the way it is juxtaposed with concepts of *body*. The goals are to expose and denaturalize these assumptions, and to build a new set of reference concepts and a vocabulary less encumbered with philosophical baggage. I critique the simplistic skill/intelligence binary, which I interpret as one of many manifestations of the culturally fundamental Cartesian mind/body dualism. I examine aspects of our digital-cultural and academic traditions and conventions which, for decades, have emphasized the overarching importance of 'information' and abstract thinking, arguing that this orientation is an impediment to a good understanding of skilled practice in the world. Skill is, fundamentally, *enacted*: it is situated and processual, it is *performed*. Perspectives from postcognitivist (4E) and phenomenological thought are introduced.

Section 2 surveys a range of relevant physiology and neuroscience, (with a contextualisation in cognitive archeology and phylogenetic neuroscience (Cisek, Pessoa), in order to develop a neurophysiological grounding for a new framework within which to discuss skill (emulating perhaps, the way Maturana and Varela reframed discussions of cognition on a biological as opposed to philosophical basis). The neuroscience of proprioception and spinal learning central in these arguments. This results in the formulation of a theory of skill rooted in a non-dualistic neurophysiology.

Section 3 focuses on skilled practices, informed by the prior philosophical critique and survey of relevant science. This section explores skilled working practices; tools and instruments as prosthetics and extensions; the organization of spaces, procedures and people in *cognitive ecologies*; and the role of representational systems in skilled practices. Experiential and the ethnographic reports are explored, deploying key concepts in 4E discourse, including epistemic action (Kirsh), cognitive ecologies (Hutchins) and material engagement (Malafouris). This section

draws upon introspective, (auto)ethnographic explorations of the experience of practice, and diverse 'case studies', from indigenous Pacific canoe carving to industrial precision machining.

Questions of pedagogy, and 'talking about' as they pertain to teaching skills, necessarily emerge. I write about skill from a background of diverse and extensive experience, yet this writing remains 'about' – it remains in the realm of know-that. One butts-up against (ETM) Polanyi's tacit knowledge and the purported 'ineffability' of practical knowledge. Can one 'represent' embodied, proprioceptive experience in literary form? The answer might be no, if one is constrained to literary forms circumscribed by the legacy of enlightenment humanism, in which (mind/body) dualism is taken to be axiomatic. Telling stories about skill does not transfer skill knowledge (know-how). Yet practitioners have always spoken about their practices in ways that are, apparently, meaningful in, and to, those communities. The role speech (or text) plays in such processes is not necessarily propositional.

One might assume that having a deep knowledge of a field would be a prerequisite for writing about it. Surprisingly, some academic disciplines have developed traditions in which familiarity with the 'nuts and bolts' (ETM) of a field is not regarded as a requirement. Art historians who don't know the basics of how oil paint works, film theorists who haven't made films. Such academics are seldom active members of their communities they study, and rarely possess experience and knowledge-bases appropriate to specialized discussions of skill. Some remain 'observers', some do learn practices, or come with relevant experience. Anthropologists, famously, do field work. But they also reside in 'trading zones' (Galison) - they work in quite different discursive universes, that privilege 'abstract' information over embodied experience (characteristic not only of the academy but also of digital cultures).

Section 4: *Skill among machines* discusses technological systems in which cognition (as well as physical work) is offloaded into machines and technologized environments. The section begins with a study of work on the industrial factory floor, where artisanal knowledges morphed into 'industrial crafts' in what I call 'the machinist's cyborgian umwelt'. Contrary to conventional rhetoric, the continuity of (industrialised) automation from mechanical electronic to digital is emphasized.

The section then focuses on the computational environments and digital lifestyles that characterise contemporary life. The issues explored in Sections 1,2,3, have immediate relevance in contemporary debates around pedagogy and educational policy, human-computer interaction, and digital cultures and technologies. The digital and network technologies that have seen historically rapid development, have become useful in the neo-liberal academy. In educational institutions, the valorisation of abstract information that is common to academia and computing makes for a smooth adoption of digitally-automated bureaucratic and

administrative functions, that offer administrative and economic efficiencies consistent with the historical uses of, and markets for, computing. (IBM, we ought recall, stood for International Business (not 'educational' or 'research') Machines). These environments of databases, spreadsheets and rule-based procedures, happen to align well with retrogressive pedagogical methods - teach-to-the-test approaches, rote-learning and obsessive 'assessment' (often automated in the form of multiple-choice quizzes and exams). They reinforce an implicit hierarchy privileging abstract knowledge, and are entirely incompatible with pedagogies involving embodied capabilities and the manipulation of instruments, tools and materials in the lab, studio and workshop.

AEVs: autoethnographic vignettes.

In attempt to ground my arguments, the text is punctuated with autoethnographic vignettes, case examples and anecdotes that bring the conversation back to lived experience.

Embodied technical metaphors (ETMs)

Throughout the text, readers will see '(ETM)' appended to some phrases. This stands for Embodied Technical Metaphor. In the process of writing, I've noticed the common occurrence of metaphors derived from embodied experience - something that George Lakoff drew our attention to in his book *Metaphors we live by* (198x). Concepts like 'grasping' and 'running' and 'stumbling' are obviously derived from immediate bodily experience. But many concepts are derived from more complex engagements with world - anyone who has climbed a tree knows the potential peril of 'going out on a limb' - the phrase is steeped in fear. You 'take the high road' and we're on different 'paths'. I may be 'talking out of my hat' - whatever that means. More pertinent to this text, there is a vast array of metaphors rooted in skilled practices, special qualities of tools, techniques and technologies. 'Forging ahead' means 'going at it hammer and tongs' (both from blacksmithing). 'Keeping an even keel', 'taking a different tack' and being 'taken aback' are from sailing. 'Undermining', comes from medieval siege warfare, 'nose to the grindstone' describes the posture of a sword-grinder. In a similar 'vein' (geology or physiology?) we 'hone' arguments. String, cord and rope figure heavily - a couple 'ties the knot', an Australian might 'spin a yarn', I've 'lost the thread'. Others pertain to textile crafts - If I argued that such expressions provide the 'warp and weft' of conceptual discourse, would I be 'pushing against the grain' or (rather gruesomely) 'flogging a dead horse'? A friend recently wrote to me "I'm just now pulling out of a nosedive". Presumably, he is now back 'at the workface' with 'shoulder to the wheel' and has the 'pedal to the metal'.

Contemporary language is replete with mechanical, optical, electronic and digital references: we 'focus in', we are 'steamed-up'. We 'have our antennas up', and we 'home-in'; unless we 'have too many tabs open'. I draw attention to examples like these in the text because they show us very clearly the way skilled practices and cognitive engagement with tools and technologies

generate a rich reserve of metaphors that build (ETM) complex concepts. Sometimes, in common parlance, the original reference (which provides the meaning of the metaphors) is unknown to the user, resulting in gaffs like 'honing-in' or 'taking a different tact' - neither of which make any sense. This is all 'grist for the mill', but none of this is worth 'a hill of beans' to 'bean-counters', of course.

Skill: Annotated Table of Contents

At present, there are ~40 chapters varying from 1.5K-5.5K words, divided into five sections (including front-matter). As of mid 2024, all listed chapters are in a long draft form except parts of sections 4 and 5. Chapters in sections 0, 1, 2 and 3 are in second draft form. Current word length of the ms is ~150K words. Below, word length for each chapter is indicated by, ie '1K'.

0. Various Introductions

0.0 Preface/Acknowledgements. 1.8K

0.1 Introduction. 4.7K

0.2 Skill and the Anthropocene. *Questions of skill with respect to sustainability debates.* 1.4K

0.3 Autobiographical sketch. 3K

0.4 Prospectus – what is this? 2.4K

0.5 In the wetlab 2K

0.6 AEV1 Painting the garage door 1.3K

1. To be done with Mind and Body. *Recovering from enlightenment - getting our bodies back. This section offers a philosophical and historical survey, outlining the construction of the concepts of mind and body from Descartes to Merleau Ponty.*

1.0 Descartes and his legacy 2.4K *Descartes' Faustian bargain. Enlightenment humanism. Cartesianism and computationalism.*

1.1 Dualisms. 1.6K *Discusses structuring dualisms in Enlightenment Humanism, and their dangers.*

1.2 How to lose your mind. 4K. *This chapter examines the historical construction of the concept of 'mind', drawing on Rorty, and Ryle, Dreyfus, Haugeland, Varela, etc.*

1.3 Inner and outer worlds. 2K. *Discusses the (apparent) comingling of inner and outer 'worlds' in human experience, consciousness and non-consciousness.*

- 1.4 Mental Representation. 3K *Discusses the idea of mental representation, outlining differing valences in philosophy, in computationalist theories of cognition, and neuroscience.*
- 1.5 Cognition, cognitivism and computationalism. 3.4K *Examines the rise of the term cognition, and its history.*
- 1.6 Skill and 'higher cognition' 3.5K *Discusses skill with respect to the idea of abstracted, generalized or dematerialized intelligence.*
- 1.7 Postcognitivism - a primer 4.6K *Introduces a range of newer perspectives on cognition: embodied, enactive, situated, distributed and materially-engaged paradigms, and how they relate to Skill.*
- 1.8 Skill and the academy 3.7K *The commitment of the academy to know-that and the denigration/devalorisation of skill.*

2. Towards a holistic neurophysiology. *I survey historical and contemporary neuroscience research relevant to the question of skill, noting dualist and holistic approaches. Elucidates some of the challenges of weaving together an interdisciplinary argument across diverse fields.*

- 2.0 The phylogenetic perspective. 3.1K *Discusses emerging perspective of evolutionary neuroscience (Cisek, Pessoa et al) as a successor to non-scientific conceptions of, for instance, 'mental faculties'.*
- 2.1 Paleocognition 6.4K *Considers our cognitive capacities in anthropological-archeological context.*
- 2.2 Proprioception 4.9K. *The neurophysiology of proprioception – regarded here as the unacknowledged, fundamental sense - and its importance in skilled action and skill development.*
- 2.3 The fascinations of fascia 3.6K *Emerging understandings of anatomy and neuroscience of fascia.*
- 2.4 Active inference: prediction and representation 4.5K *This chapter surveys the emerging neuroscience of active inference, predictive processing, and the Free Energy principle.*
- 2.5 Neuroplasticity and Spinal Learning. 4.7K. *The motor-pools in the spine serve as intermediary sites between brain and body managing motor functions, in tight feedback with muscle innervations.*
- 2.6 Aphantasia – memory, imagery, mental rehearsal. 4.6K *Explores imagination with respect to sensory acuity and its relevance to skill.*
- 2.7 How do we learn a skill? 5.1K *This chapter probes how we know about our own body, how such awareness is developed, and what the nature of that knowledge is.*

- 2.8 Ecological validity and the white box 2.4K *Discusses laboratory experiments with respect to ecological validity (Neisser) and ethology. Kirsh's Epistemic Action as a case study.*
- 2.9 Towards a holistic neurobiology 4.1K. *Outlines proposal for a non-dualist neuroscience that does not separate brain and body. Critiques brain-chauvinism.*
- 3. Cognitive ecologies of the atelier.** *Artisanal knowledges, intelligence in action. Cognitive dimensions of skilled practices. Anthropological and historical examples, including traditional and indigenous skill knowledges and what I call Industrial Crafts.*
- 3.0 Putting mind body and world together again, again. *This chapter binds what preceded it with what follows, discussing skill with respect to a neurophysiological conception of "organismic holism".*
- 3.1 Tools, skills, incorporation. 4.9K *Examines the bodily dimensions of tool use. Incorporation, prosthetics and peripersonal space. Heidegger's Zuhandheit, Bateson's 'blind man's stick'.*
- 3.2 Structured spaces and cognitive ecologies 5.2K *Explores the extended qualities of cognition in structured workspaces. Situated and distributed cognition, cognitive ecologies.*
- 3.3 Contingent representation: sketches, scores, working drawings. 2.4K *Considers various kinds of notational systems in the service of know-how - as opposed to the symbolic reduction of 'the world' to symbolic 'facts'.*
- 3.4 Creativity, Hylomorphism and the dance of agency. 4.8K *Takes up Ingold's critique of the idea that creative thought precedes creative act. Juxtaposes with generative emergence, process and performativity.*
- 3.5 Artisanal Knowledge. 4K *Historical discussion of the place of craft and artisanry wrt science and philosophy - draws on S.Schapin, P. Smith, etc. Tacit knowledge and the artisan community.*
- 3.6 Pacific seafaring and navigation 4.6K *Non-western case examples in the bodily dimensions of non-western knowledge systems. Wave piloting and stick charts.*
- 3.7 Teaching and learning skills. 2.3K *Pedagogies of know-how, skill, and the place of skill-knowledge in pedagogy generally.*
- 4. Skill among machines.** *This section discusses technological systems in which cognition (as well as physical work) is offloaded into machines and technologized environments.*

Contrary to conventional rhetoric, the continuity of (industrialised) automation from mechanical electronic to digital is emphasized.

4.0 Machine tools and automation *Offloading cognition in cyborgian systems.*

4.1 Industrial Crafts 4K *Historical contextualization of mechanized artisanal trades that emerged in the industrial revolution. Examines the skill in precision metalwork.*

4.2 Cognitive ecologies on the shop floor. *The machinist's cyborgian umwelt* 5K

4.3 Born digital. *Discusses cognitive dimensions of digital cultures, from the perspective of embodied skill-building, changes in cognitive capacities in screenal, low-touch cultures.*

4.4 Skill in the digital. 4.5K *Inquires into the status of on-screen procedures and representations as tools, and the metaphorized nature of skills in representational environments. Embodiment in virtual worlds: virtual kinesthetics, virtual embodiment among avatars and 'non-player characters'. The virtualisations and dematerialisations of skills: CAD, MIDI, gaming, VR*

4.5 Models and Simulations 3.3K *Discusses the phenomenon of active simulatory environments as entirely representational environments, where design choices have been made with regard to salience and simplification (the map not being not territory).*

4.6 STEM and digital cultures. 3.3K. *I addresses questions of pedagogy, and specifically issues around STEM pedagogy - and the attempts to address/redress perceived shortcomings, in what has come to be known as STEAM.*

4.7 AI, Intelligence and (the concept of) mind. *Discusses the relevance of the book to (the rhetoric of) AI, as rooted in dualistic notions of mind and brain, and the nature and location of, 'cognition'*

Epilogue - The ineffable. Embodied experience and academia. 1.5K *A conclusion regarding communities of knowledge and deployment of language.*

5. End matter

5.0 Notes

5.1 References. *A comprehensive set of references is built for current draft, in Zotero.*

5.2 Index

Simon Penny – Brief Biography

Simon Penny is an artist, teacher and theorist with a longstanding focus on emerging technologies, embodied and situated aspects of arts practices, and critical analysis of digital cultures. He is a lifelong maker and environmental activist with a focus on sustainability and green technologies. He trained as a sculptor and, as part of a pioneer generation building interactive artworks in the 90s - he developed custom interactive, VR and robotics projects. He is building an experimental sailcraft (Orthogonal) based in the design and dynamics of Micronesian voyaging canoes. He published *Making Sense: Cognition, Computing, Art and Embodiment* in 2017 (MIT press) and the anthologies *Critical Issues in Electronic Media* (SUNY 1995) and *Machine Culture* (ACM SIGGRAPH 1993). He has published over 100 peer reviewed papers and chapters in diverse disciplines. He directed *A Body of Knowledge: Embodied Cognition and the Arts* conference UCI 2016 and *An Ocean of Knowledge - Traditional Seafaring, Sustainability and Cultural Survival conference, UCI 2017*(both with NSF funding). Born and educated in Australia, as Professor of Art and Robotics at Carnegie Mellon (1993–2000). He is co-director and co-originator of the *Industrial Crafts Research Network*. Penny is professor of Electronic Art and Design (Dept of Art) at University of California, Irvine, where he built the Arts Computation Engineering interdisciplinary graduate program. He has appointments in the depts of Music and Informatics. He teaches *Art and Sustainability; A Cultural History of the Anthropocene; Embodied Cognition and the Arts*, and *How to be Clever with Stuff*, among other classes. More at simonpenny.net

Relevant recent publications

Monograph: *Making Sense – Cognition, Computing, Art and Embodiment*. MIT press. Dec 2017.

Papers/chapters forthcoming/in press:

- *Designing behavior: interaction, cognition, biology and AI*. Encyclopedia of New Media Art (ENMA Vol II). Bloomsbury Publishing plc, UK.
- *Aesthetics, interaction, and Artificial Intelligence: contextualizing first generation Media Arts*. Encyclopedia of New Media Art (ENMA Vol III). Bloomsbury Publishing plc, UK.

Papers/chapters published 2018-2024

- *An eco-ethics for the end of the Anthropocene: Finding ethical and sustainable paths through consumerism, disposability and planned obsolescence*. Maintenance and Philosophy of Technology: Keeping Things Going. Eds Mark Thomas Young, Mark Coeckelbergh. Routledge. 2024
- *Living in Mapworld: Academia, Symbolic Abstraction, and the Shift to Online Everything*. Constructivist foundations 18/2. 2023 <https://constructivist.info/18/2/188.penny>
- *Ancient Voyaging Capacity in the Pacific*. Peter Nuttall, Marianne George, Simon Penny. The Cambridge History of the Pacific Ocean. Cambridge University Press. 2022

- *Sensorimotor debilities in digital cultures*. AI & SOCIETY, 2021. DOI 10.1007/s00146-021-01186-0 <http://link.springer.com/article/10.1007/s00146-021-01186-0>
- *All the things that used to be computers, and all the things that weren't and still aren't*. Published in French in *Le Comportement des Choses*, Edité par Emanuele Quinz. Les Presses du Réel. Dijon. FR. <https://www.lespressesdureel.com/ouvrage.php?id=8611> 2021
- *Canoe-carving, Lamotrek style: An interdisciplinary study in crafting, design, engineering, and sustainability*. Form Akademisk, Sweden. Vol 13, No 1. 2020
- *Twist-hands and shuttle-kissing: Understanding Industrial Craft Skills via Embodied and Distributed Cognition* Form Akademisk, Sweden. Vol 13, No 1. 2020 (co- author Tom Fisher, Nottingham Trent University, UK)
- *Making as critical interrogation - an autobiographical reflection*. Craft Research Journal (UK) October 2020.
- *Trying to be Calm: Ubiquity, Cognitivism, and Embodiment*. (by Simon Penny. Translated by Zhongmei Zhang). Benchao, Wang, Weisheng, Xiao eds. Journal of Hou Xueheng (2). Chongqing: Southwest China Normal University Press, 2020. 80-93.
- *From Bacteria to Bach and Back* (A review of Daniel Dennett's *From Bacteria to Bach*) in AI & SOCIETY. Springer-Verlag London Ltd. Vol34, 2019 pp383–386 <https://doi.org/10.1007/s00146-018-0797-9>
- *Enactive–performative perspectives on cognition and the arts*. In AI & SOCIETY. Springer-Verlag London Ltd. 2018 <https://doi.org/10.1007/s00146-018-0801-4> .

A comparison of *Skill* to other books in the field

To my knowledge, no book like *Skill* exists, if the book is framed as an interdisciplinary treatment of embodied, artisanal and clinical skill(s), drawing upon 4E theories of cognition, anthropology, neuroscience and philosophy. No book, to my knowledge, grapples with the neurophysiology of skilled practices in an explicitly non-dualist way. There are many (kinds of) books that border on the general territory in different ways - some of which are listed below.

Lambro Malafouris' *How things shape the mind* (MIT 2013) was an important intervention, drawing on similar resources as I do, but focuses on issues in cognitive archeology. Tim Ingold's *Making* (Routledge 2013) is a lovely and important volume of anthropological perspectives. Similarly *Making Knowledge* (2011) (editor Trevor Marchand): some of the contributions (including Marchand and Downey) broach issues central to *Skill*. Bicknell and Sutton's recent *Collaborative Embodied Performance: Ecologies of Skill* (Bloomsbury 2022) is close in spirit to *Skill*, but its focus is on collaborative performance.

High points in the phenomenologically-informed philosophy of cognition include Andy Clark's oeuvre (*Being There*, *Supersizing the mind*, *Surfing uncertainty* etc) Michael Wheeler's

Reconstructing the Cognitive World (MIT 2005) and Anthony Chemero's *Radical Embodied Cognitive Science* (2009). Mark Johnson's *The body in the mind* (1987) remains relevant, as do Lakoff and Johnson's *Philosophy in the flesh* (1999) and Maxine Sheets Johnstone's *The primacy of movement* (1999). Shaun Gallagher's *How the body shapes the mind* (2005) shares philosophical touch-points, but does not deeply engage practice.

There are numerous works in anthropology that bear upon this subject but are not focally concerned with it – such as Kathryn Linn Guert's *Culture and the Senses: Bodily Ways of Knowing in an African Community* (2003). There is an important class of anthropologically and ethnographically oriented works from the 1990s that, sadly, came too early to draw upon subsequent developments in embodied cognition. These include Keller and Keller's pioneering study, *Cognition and Tool Use– the blacksmith at work* (1996), Sudnow's *Ways of the hand* (1993) and Harper's *Working Knowledge* (1992). In a similar vein, Frank Wilson's *The Hand* (Vintage, 1999) is a fine book, grounded and interdisciplinary, that would have profited from 4E perspectives.

Pamela Smith's *The Body of the Artisan* (Chicago 2004), and more recently *From Lived Experience to the Written Word* (Chicago 2022) are excellent studies, historically located in early modern period. Christopher Bardt's *Material and Mind* (MIT 2019) ventures into this territory but is design/architecture centric, and as such, butts up against the hylomorphism that is inherent in those disciplines. Chris Baber's *Embodying Design: An Applied Science of Radical Embodied Cognition* (MIT 2022) applies embodied cognition to digital design practices. *Abstracting Craft* (McCullough, MIT 1996) some makes arguments I explicitly reject. Richard Sennett's *The Craftsman* (Yale 2008) is a (rather too) scholarly treatment, more often citing ancient Greek sources as touching down to actual practice. Psychologist Nancy Dess' anthology *A multidisciplinary approach to embodiment* (Routledge Focus 2021) offers a broad selection of specialized topics but few address embodied experience in tangible detail.

Some of the topics discussed in *Skill* have been the territory of what the medical establishment calls 'complementary medicine' around which debates on pseudoscience still rage - *The Body Keeps the Score Mind, Brain and Body in the Transformation of Trauma* by Bessel A. Van der Kolk 2015 is a well-known example. A current case is Robert Schliep's *Fascial fitness* (2021). *Bone, Breath and Gesture* (ed: Johnson, 1995) is a more academic anthology that includes discussion of the work of many 'body-work' pioneers, like Ida Rolf and Moise Feldenkrais.

At the more popular end of the spectrum, *Skill* shares sentiments with *Zen and the Art of Motorcycle Maintenance* (Pirsig 1974) and *Shopcraft as Soulcraft* (Crawford 2009).

The book's target audience(s).

This book was originally conceived as an interdisciplinary treatment of embodied cognition that would provide an up-to-date discussion of theory and science relating to cognitive dimensions of skilled practices. As such it speaks directly to artists, craftspeople, and also to those concerned with theorizing such practices, such as graduate students in anthropology, psychology, cognitive science, sociology, education and arts theory - especially in interdisciplinary practice/theory contexts referred to as research-creation, practice-driven research, research-driven practice and performance and improvisation theory. Academically, the work has relevance to more interdisciplinary sectors of the anthropology, sociology, psychology, cognitive science and philosophy communities engaged in consideration of skilled practices, as well as specific disciplines such as sports-science. It is relevant to those in informatics, developmental psychology and education negotiating questions of embodied skills with respect to (the potentially deskilling effects of) digital cultures, especially developmentally in children. These issues are also of interest in education, architecture, museum design, sport-science, and interdisciplinary sociological and anthropological research centers (such as the Centre for Elite Performance, Expertise, and Training (CEPET) at Macquarie University, Australia). More generally, a large community devoted to complementary medicine, therapeutic body-work, martial arts, and Buddhist philosophy have an interest in reconciling western dualist notions with more holistic approaches to embodiment.