Embodied, Disembodied and Re-embodied Cognition: the Potentials and Obstacles for Elegant Human–Computer Interfaces

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Abstract

It is clear that the ingenuity of brain interface technology will create significant changes in human lifestyles of the 21st century. Applications such as haptics, virtual reality, mind-reading computers, and perceptive pixel screens are pure genius. One can easily foresee the impact these developments might have on future generations.

Concurrently, a close intellectual neighbour, Enactive Cognitive Science, has been studying the dynamics of change in living systems. The enactive view of consciousness was introduced by the late Francisco Varela at CREA/LENA laboratories (Paris), one author of The Embodied Mind: Cognitive Science and Human Experience [1].

This paper will briefly explain Varela's neuro-phenomenological model for laboratory experiments, which could easily find a place within brain interface technology. We will also propose an unusual adaptation of this model: by working with specialists with exceptional psychophysical expertise in high proprioceptive performance, engineers can come closer to the truly elegant human-computer interfaces they seek.

1. Introduction

A successful technological future will require collaboration between researchers who enthusiastically explore disciplines as widely separated as the philosophy of mind and high performance training. Extradisciplinary input can often shed unusual and sometimes uncanny light upon mysteries that the constraints of one's own discipline cannot articulate. The inherent skills of these researchers must include a certain tolerance for *otherness* and a willingness to construct a new, interdisciplinary vocabulary capable of expressing what enactive cognitive science calls *neurophenomenological* evidence. A truly coherent analysis of enactive systems must cast its net of observation over multiple logical levels, widening its scope until a suitable embodied vocabulary can be constructed.

Francisco Varela insisted that laboratory science must develop methods for experimenting with and validating *awareness* of our *lived experience*. He modelled embodied cognition under laboratory conditions which required input from "first-, second- and third-person" sources. In this vein, he introduced a phenomenological vocabulary in order to better express the subtle relationships between the first person *subject* (e.g. the lived experience of a physically disabled person or a high performance artist) and the researcher (a laboratory engineer or technician with her third person scientific constraints). He even went so far as to introduce the "second person" (e.g. a trainer, coach, psychophysical specialist) into this interface as a significant catalyst in the experimental process [2].

This second person is the primary focus of this paper. Ideally, he or she is a *psychophysical specialist* in physical rehabilitation and/or highly skilled in proprioceptive performance. This specialist would study the embodied dynamics of the specific interface area being researched, and draw attention to critical moments in the psychophysical process of which the scientist has no working knowledge.

Such an intermediary will introduce a broader vision of the experiment and maintain focus on improving the internal psycho-sensory coordination of the subject, thereby improving the quality of performance achieved in the experiment. The expertise brought by the second person provides an unusual opportunity for the researcher to document the precise improvement of the subject's embodied *use* in relation to their manipulation of or by the technology.

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2. Embodied cognition

"The emergence of embodied dynamicism in the 1990's coincided with a revival of scientific and philosophical interest in consciousness, together with a willingness to address the explanatory gap between scientific accounts of cognitive processes and human subjectivity and experience." [3].

In particular, the enactive approach of Varela, Thompson, and Rosch [1] introduced a new definition of cognition as "…the exercise of skilful know-how in situated and embodied action". This quality of being *situated* is an essential ingredient: the subject and scientist are seen as existing within the "conditions of possibility" [8] of living organisms, who are in the process of using an *as if* proposition of third person objectivity to create falsifiable laboratory data.

"The blind spot in the cognition sciences of the 20th century is that we do not have a method of properly accessing experience…

To deprive our scientific examination of this phenomenal realm amounts to…amputating human life of its most intimate domains, or else denying science explanatory access to it." [3].

Figure 1. Francisco Varela (1946-2001)

Their embodied enactive model has affected many related disciplines. For example, Thelen and Smith [4] applied dynamic systems theory to the enactive development of proprioceptive intelligence in children. It is very clear that the vestibular system is deeply connected to brain development before and after birth [5]. Today in biology and neuroscience, we find a recent and very strong interest in what is now called "the lost sixth sense" [6,7], the collaborative triad of vestibular, visual, and proprioceptive systems. Simply put, it means knowing where you are kinesthetically in relation to your most constant environmental influence: gravity. Researchers look for intra-species clues in evolution, in embryology, and throughout early childhood development. In this light, the quest of an *enactive* oriented scientist is to discover the *autopoietic* (self-organising) [8] logic that brought humans to upright bipedal posture. No one needs to teach a child to crawl, scoot, sit, and find its way to bipedal existence. This is no small task, as anyone who has ever been physically disabled knows. Interestingly, the most sophisticated psychophysical specialists show patients how to *re-access* rather than re-learn this autopoietic know-how during rehabilitation. These methods are non-coincidentally the same methods used in high performance training. The goal of both is *psychophysical congruence*, especially when adding a new skill such as the pole vault or playing a musical instrument.

Studying proprioceptive awareness in infants reveals a process so profoundly intelligent that when we have seen it, there can be no doubt that cognition is embodied from the very beginning. In fact, a great deal of this research on the "lost sixth sense" is driven by the practical problem of proprioceptive and vestibular disorientation in micro-gravity, which can leave astronauts as helpless as infants. Equally applicable to NASA research are cases like "Ian Waterman who, at the age of nineteen, lost the senses of touch and movement and position sense, relearned, over 2 years, to move by thought and by visual supervision." [9]. The sense of *agency* which a child develops by learning to lift and orient its head turns out to be a key element in both evolution and the ability to develop more refined skills. The loss of this *know-how* is a loss of self. By ignoring the significance of this basic sense of self, we humans have managed to *lose* touch with an essential intelligence. We have replaced it with a pretense: the disembodied intellectual agent. Enactive cognitive science attempts to correct this mistake. How this disembodiment comes about and how it may be resolved is also the focus of psychophysical specialists.

3. Disembodied cognition

Enactive *disembodiment* of mind is often overlooked by philosophers and even neuroscientists. It is a very difficult subject to approach because it challenges the *beholder* in the same way that the child in the story "The emperor has no clothes" strips cherished *as-if* beliefs from the powerful.

As the reader may remember, there is a traditional discussion in the philosophy of science which is called the *mind–body problem.* It is usually attributed to the writings of René Descartes in the seventeenth century, though strains of this problem can be traced back to the early Greek philosophers. In 1623, Descartes dared to put all that he thought to be real in doubt and even went so far as to question his own existence. Unfortunately, his conclusions about separate but interacting mind and body and his quest for *certainty* in a yet undiscovered quantum world have proved to be in error. The side effects of these errors are not easily undone. They manifest as mind-body dissociation, and

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in the worst case as *dissociative disorder,* a serious psychological pathology.

How could this come about? It turns out that the initial signs of dissociation can occur during a child's early developmental cycle or first school years. According to Daniel Stern, children develop their core sense of "self agency, self coherence, and self affectivity" between two and nine months [10]. In the 1930's, Myrtle McGraw observed that self-consciousness and self-confidence develop along with the proprioceptive mastery of stable bipedal coordination. [11]. Lise Elliot describes several developmental benchmarks: 2 years for an awareness of "I", "Me" and "Mine"; 3 years old for the beginnings of cognitive differentiation between *reality* and *appearance*; 3-5 years for a "theory of mind" capable of distinguishing memory, dreams, desires, beliefs, and imagination; and 6 years for universal brain maturation manifesting as skilful drawing, language, memory, attention, control, and self-awareness [5]. During these tender cognitive ages, children are spontaneous learners with predominantly neuroplastic brains. And it is precisely then that the greatest potential for dissociation occurs. At six years old if not earlier, children are expected to spend many hours a day in school, many days a year.

For the most part, they are taught to transfer their allegiance from first person lived experience to third person validation of their worth. In many cases, this induction into Cartesian duality happens at far too young an age. It creates a profound disruption in the newly formed *self* that arose from psychophysical know-how about horizontal and vertical negotiation of gravity. It is this dissociation from first person know-how that makes it particularly difficult for adults to re-learn walking or even to begin to move an arm after a stroke.

The lingering treatment of the body as a third person object, a non-reasoning, irrelevant but necessary condition of existence is the result of mind-body dualism embedded in our culture, education and beliefs about mind. It lingers like a resistant artifact even as new research completely invalidates its premise. For example, the highly publicised results of *mirror neurons* [12] and *brain neuroplasticity* [13] have severely upset previous beliefs about *closed systems* on the one hand and the *unchangeability of the mature brain* on the other. Not only has quantum mechanics shown the observer to be an essential *participant* in any system, we now think that mirror neurons are constantly influencing and being influenced at an interactive level of neurological simulation. Therefore, every psychophysical attitude and incident of communication is immediately mirrored and/or simulated by the receiving brain—regardless of whether a laboratory technician thinks she is in an objective (disembodied) state of observation. There is no doubt that third person scientific constraints are useful. It is the side effects that concern us deeply.

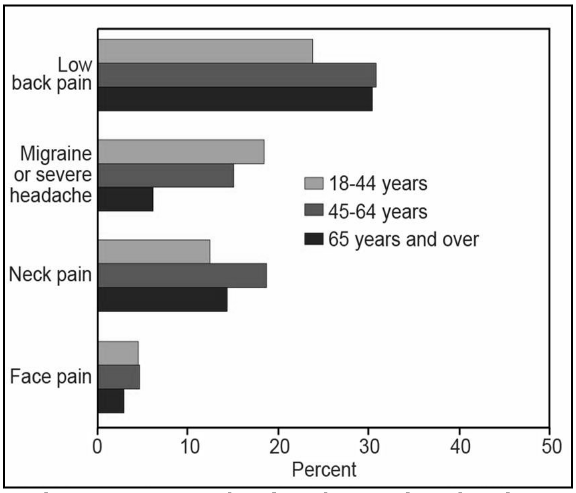

Figure 2. Lower back pain, neck, migraines and face pain, in the past 3 months (2004)

In Figure 2 we can see examples of these side effects, which we consider in most cases to directly result from the patient's lost sense of agency. They only notice the trouble when it has reached chronic proportions. Psychophysical experts have watched the proprioceptive genius of children deteriorate rapidly after they enter school, where they must sit for lengthy periods, often in chairs inappropriate for their size.

We know that it takes many months, even years, for monks to be trained to sit in stillness and to concentrate simply on their breath. It is not surprising that children, without any training whatsoever, gradually become dissociated to avoid the discomfort of their bodies.

This subject is actually relevant to the new technology because it is rarely addressed and also because it is a blind spot in our culture. A stroke patient or paralyzed patient being taught to use interface technology carries an underlying dissociation that will affect the experiment. In addition to designing these amazing new interfaces, it should be possible to improve the *internal* interface between the subject's body and mind. This is what the second person specialist knows how to do. It would be a waste not to implement this sophistication at the beginning of all these wonderful inventions.

4. Re-embodied cognition

We will now consider high performance psychophysical activity, a category which will include physical rehabilitation. (A physically disabled person and an athlete working to gain that winning second face similar proprioceptive challenges: in both cases, the refined skill takes place in micro movements.) The dedication necessary to relearn movements that for so long had been taken for granted is, in our view, a high performance discipline. The first step in the process is the re-association of mind and body. Dissociation is so common that it goes unnoticed until a crisis demands a change. Returning the mind to its moment by moment engagement with proprioception recalibrates the nervous system into psychophysical congruence.

A most obvious symptom of common dissociation is the lack of sensorial definition, the lack of a positive sense memory in particular. It is interesting that we all want to feel good, but when asked to be very precise in our definition of that desire, most are hard put to state sensory data clearly. When it comes to pain, we are often much more precise. No doubt it has been an evolutionary advantage to deeply embed memory of danger rather than pleasure, an adaptation for the purpose of long-term survival. In high performance activity, a break in congruence is often the most difficult obstacle, only surpassed by the dissociated internal negative critique.

What do these second person psychophysical experts do to re-embody the minds of people who are attempting to surpass Olympic records, sing at La Scala, or operate a wheelchair in a world made for walking?

They begin with basics. They analyze how the subject is using their autonomic nervous system, which either limits creativity in favour of immediate survival or opens the nervous system to aesthetic invention. Figure 3 diagrams the basic structure of the autonomic nervous system, with its two branches:

On the left, the sympathetic (fight or flight) system dilates pupils, inhibits salivation, accelerates respiration, accelerates heart beat, inhibits digestion, secretes nora-adrenaline, increases sweat, raises “goose bumps”, relaxes bladder, and stimulates orgasm.

On the right, the parasympathetic (rest and digest) system constricts pupils, stimulates salivation, relaxes respiration, slows heart beat, stimulates digestion, decreases sweat, relaxes hair follicles, constricts bladder, and stimulates sexual arousal.

In order to re-embody the mind, it is necessary to know whether the sympathetic or parasympathetic system is dominant. Usually it is the sympathetic that is overactive. Of course, a subject in an experiment is going to be flooded with insecurities, doubts, fears of failure, fear of disappointing the researcher, etc. It is important to remember that most human beings in an unknown experience often become anxious. Their performance during an experiment therefore may not fairly represent their true capacities. Sympathetic dominance limits awareness of the present moment to that which is necessary for survival. Therefore, it eliminates aesthetics, subtleties, and the creative genius that is possible in the parasympathetic state. High performance requires an adaptable union of parasympathetic calm and excited precision of the sympathetic. If either one becomes too dominant, the *edge* of performance is lost.

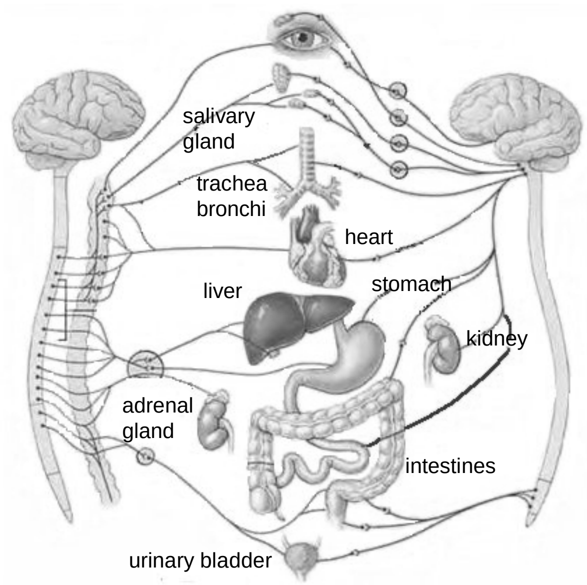

Figure 3. Sympathetic vs. Parasympathetic

In the case of an enactive interface laboratory subject, particularly someone like a quadriplegic who has already lost proprioceptive control of her existence, the stress induced by self-criticism always waits in the shadows. It anticipates the condescension of the technician, who may be so invested in technology that the enactive interface only receives lip service.

It was very encouraging to find a research focus on the laboratory subject’s stress during the enactive interface XVR workshop. Guenter Edlinger (Guger Technologies) included stress feedback (via Galvanic skin response) in his experiments. The team of Roberta Carabalona and Paolo Castiglioni (Don Gnocchi Foundation, Italy) monitored the effect that a disruption in virtual technology, which they call *a break in presence*, has upon laboratory subjects. In the performing arts, a break in concentration is said to break the *intimacy of space.*

Psychophysical specialists often find that this sort of disruption is followed by an irrational, hallucinated fear and a shift into dissociated (third person) negative critique. Unfortunately, the resulting loss of performance can escalate in mere seconds. High performance training shows people how to return to a more parasympathetic state of awareness. In essence, psychophysical specialists have learned how to train the autonomic nervous system.

There is a link between Enactive Cognitive Science and psychophysical methodologies. In the book *The View From Within: First-person approaches to the study of consciousness* (edited by Varela), Carl Ginsberg mentions two methods in particular [14]. The first was developed by F.M. Alexander in the late 1800's, and he continued to refine his *Alexander Technique* in the early 1900's in England. [15]. One of his greatest supporters was none other than Sir Charles Sherrington, who received the Nobel Prize for his explanation of how it would be possible for the nerves, originating in the spinal cord, to communicate through neurons and synapses, and by so doing to organise the entire body in the maintenance of posture [16]. Sherrington also coined the term "proprioception."

The Alexander Technique is based upon a discovery of the importance of a gravity-sensitive (dynamic) positioning of the head in relation to the function of the spine. This discovery was supported by the work of R. Magnus [17] on *righting reflexes*, which he called *central control*, and later by Alain Berthoz [6]. Highly skilled teachers help students of the Alexander Technique retrain their natural head/neck coordination, stimulating a conscious awareness of this relationship as the student refines a new skill. High performance artists thrive with this kind of gentle but very precise psychophysical control. It makes their performance effortless and at the same time inspired.

The second method was introduced in the 1950's by Moshe Feldenkrais, a Russian, French-trained physicist and engineer who experimented with many different physical sports and studied the methods of those rare psychophysical specialists that existed in the first half of the 20^{th} century. His genius was to combine sequences of infant proprioceptive dynamics, his knowledge of physical forces, and a profound understanding of the human nervous system. He invented 600 movement experiments that re-establish access to original proprioceptive intelligence. He discovered that by re-enacting movement patterns, one can re-learn or even learn for the first time steps in developmental coordination that might have been missed. These exercises are called *Awareness Through Movement*. [18].

The training received by teachers of these two methods is so far in advance of most physical therapies that they have a devoted following by students at the highest artistic and athletic performance levels. Both methods may be studied individually or in group lessons. The Alexander Technique is taught in every major theatre and music school in the world; the Feldenkrais method has also been integrated into dance and theatre training.

I have provided brief definitions of the two methodologies as background. I am not suggesting that specialists actually teach these methods during laboratory experiments. Rather, they are ideal providers of *second person feedback*. They can improvise on the spot, and mediate between all the interfaces in the loop of the experimental system. As an interdisciplinary group, they have begun to study the vocabulary and concepts of neuroscience and interface technology. They attend lectures and maintain dialogues with philosophers, technicians, researchers, cognitive scientists, and engineers. They educate each other in their conferences. Their primary *modus operandi* is non-intrusive intervention. I believe that their exceptional experience and dedication will be useful to scientists and engineers.

Just as the enactive interface engineers are at the leading edge of their disciplines, this growing group of psychophysical experts have a fundamental interest in eliminating the errors of disembodiment for the children of the future as well as assisting in the design of rehabilitative equipment for the disabled.

5. Conclusions

An embodied perspective on dynamic systems allows everything and everybody involved in the experimental system to be recognised. The rigor of this comprehensive view accepts the scientist's preference for a reductionist validation without sacrificing the significance of the human experience. We are now at a stage where interdisciplinarity must be the watchword of the future. Up till now, we have assumed that the third person position had attained its full identity. If we had spent the last few centuries exploring embodied objectivity, however, we would probably have discovered the state of *engaged detachment* without any loss of rigor—and with far less back pain. High performance specialists base their performance on a fluid perception of inner and outer experience.

During the 20^{th} century, the highly respected American anthropologist Margaret Mead was a voice of reason that helped guide the American population through their post-war cultural upheaval. She was a founding member of the famous Macy Conferences, which gave birth to Cybernetics and opened the post-behaviourist path to Cognitive Science. If she were alive today, she would be fascinated but cautionary, reminding engineers of the responsibilities associated with transforming a culture. She would suggest that whether technology destabilises a culture is likely to depend on *how* it is introduced to the population: it could create more disembodiment, or it could improve human potential by stimulating psychophysical congruence.

From a sociological perspective, we have before us a greying population still struggling with computer fluency and mobile phones, while the next generations learn to open a computer program as easily as a refrigerator door. As children begin to relate to robotics in the same way that their grandparents may have related to television, we can expect an even more awkward generation gap to develop. Sensing the enormity of the change before us, a new transdisciplinary interest is awakening in both enactive cognitive science and psychophysical experts who feel a need to participate in whatever future interface engineers have the courage and the skill to create.

If Susan Greenfield, in her book *Tomorrow's People: How 21st Century Technology Is Changing the Way We Think and Feel* [19], is right about a future house computer that will monitor our life signals and operate as an external homeodynamic regulator of our well being, the second person expert is an essential catalyst. Such an interface cannot be accomplished with only a third person model.

The need is for technology that enhances congruent, embodied cognition. In this light, our responsibility is to consider a wider view of what could go wrong if truly embodied cognition is *not* included in future technology. Likewise, it falls to us to imagine what could go very right if enactive engineers sat down to plan a future with their neighbours, enactive cognitive scientists.

6. Figures

Figure 1. Francisco Varela: photograph courtesy of Amy Varela and Michel Bitbol.

Figure 2. Lower back pain, neck, migraines and face pain, in the past 3 months (2000). Sources: Center for Disease Control and Prevention, National Center for Health Statistics, United States, 2006, Fig. 30. Data from National Heath Interview Survey.

Figure 3. The autonomic nervous system: Psychology Image Bank, McGraw Hill.

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