Book Review

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Brain Art: Brain-Computer Interfaces for Artistic Expression
by Anton Nijholt
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Brain Art is a big book (500 pages) with 17 chapters written by various authors that exhaustively covers a topic that has been fringe for way too long – the human brain and its extraction of electrical signals to make art. Brain art, which the book defines as the "transmutation of neural signals into realms of sounds and images that render the internal workings of the mind perceptible" declares "artists are the clairvoyants in our society." This definition sets up the book to be about visionary art – which it is, and also is not. Sure to become the standard go-to read on brain art in the future, it should have been subtitled brain art and its use in scientific and therapeutic research. It contains a lot about the history of brain sensors development into trackable EEG readings and other signals, but except for a few forays into sound art there is no profound art historical look at situating the art in brain art within the history of new media art, which is where it squarely belongs. Nina Sobell who, in 1973 created a visual non-verbal telepathic brain event between two people astutely observed "The medium shapes the social and aesthetic attributes of interpersonal exchanges."

In 1965, sound artist Alvin Lucier made music from his own alpha wave brain signals, collaborating with Edmond M. Dewan of the Air Force Cambridge Research Labs setting up the fraying of boundaries between military research and brain art early on. Others followed like visual artist Sobell, mixed media and sound artists David Rosenboom, and Richard Teitelbaum. In 1973, a scientific research paper by Jacques Vidal discussed the 'evoked responses' of the brain to external stimuli, but it was not until the millennium that clinical applications of brain computer interfaces (BCIs) took off. These applications use the brain measurements of alpha, beta, theta, and delta waves, as well as the event-related potential (ERP) P300 signal, which in layperson's terms means the signal that appears in your brain when you recognise something. The 300 comes from the 300th of a second it takes the signal to elicit a brain response. Dewan later published his results in a scientific paper explaining that people could learn to control their own alpha rhythms. In the late 1960s, Manfred L. Eaton, another early researcher mentioned the need for therapeutic and educational investigations into the brain. This stance highlights the baked-in tensions between the clinical, social and useful deployments of BCIs vs. pure artistic speculation. Brain art bends to the service of science and the social good, and rarely, if ever does science or the social good bend to the service of brain art. This hard truth reflects the fact that science and social science

research control the flow of grant money and capital into experimental brain practices, and not vice versa.

Flora Lysen discusses rudimentary EEG feedback systems of the 1930s and 1940s that functioned as early warning systems for pilots and motorcyclists. She situates early artistic explorations with BCIs within the field of self-exploration, grounding it in Foucault's concept of 'technologies of the self', Gregory Bateson's theories of the 'cybernetics of the self' and as part of a movement of the 'circuited self', a term that oddly enough emerged in tandem with the word 'interface'. When Videal's UCLA's Brain Research Institute in Los Angeles came up with the idea of a BCI, it was part of a 'man-computer dialogue' in which the interface was, in essence, the work. Mirjana Prpa and Philippe Pasquier are clear to delineate between an artwork and a 'science project', a point that should have served as a clear framing mechanism for the book's later chapters. Artists were interviewed to discuss the design of the devices, with artists compared to neuroscientists who discover the brain through new tools.

In 1924, the German psychiatrist Hans Berger recorded the electrical activity of the human brain by discovering the alpha wave, nicknamed 'Berger's Wave'. Mapping those frequencies soon followed through a meeting of the Cambridge Physiological Lab. However, it was not until 1999 in New York that the First International Meeting On BCIs finally happened. A taxonomy of categories are delineated that are, for the most part non-invasive, a major exception being the human cyborg Neil Harbisson who implanted a device into his skull, though it was not an EEG device. These categories are *input*; *mapping*; *output formant*; and *audience*. Most brain artworks are combinations of these methods. There are also four basic types of BCI controls; *passive* that relies on preprogrammed artist material; *selective* interaction, that allows the user to control emotions that change the end result; *direct*, where the user choses specific outputs like musical notes or brush strokes; and *collaborative*, meaning multiple users interact either individually or with one another to produce a work.

David Rosenboom and Tim Mullen look at the crossover between cybernetics, computer science, neuroscience, systems theory, AI, evolution, complex adaptive systems, studies in cognition and consciousness, and epistemology. Rosenboom named his compositions 'propositional music', a type of signal processing dependent upon the aesthetics of the manipulator of the signal. Multi-agent brain computer musical instrument (BCMI) are discussed that are programmed to play a game of *Alpha Checkers*. In the game, the computer screen displays a checkerboard for two players, but only if the two players produce EEG alpha waves strong enough to cross a preset amplitude threshold simultaneously. The 'goal' of making a game out of the control of the brain has sadly led to its logical outcome in a new generation of gamers. Some become so addicted to playing they do not eat, go to the bathroom, bathe, or relate to others. A slew of tech companies, including Apple and OpenBCI in conjunction with the Tobi eye trackers are now en route to making immersive brain gaming devices even more of a substitute for reality.

Suzanne Dikker, Sean Montgomery and Suzan Tunca ask a critical question that researchers are well advised to take into consideration – do the works created with BCIs stand on their own regardless of their usefulness as research experiences? Their investigations center on how we synchronise with others, and if this synchronisation tells us something vital about human connectedness, or is just a projection of our intentions onto these interfaces. The brain is described as an oscillator, since each of its 100 billion neurons individually oscillates. Speech, audio and visual stimuli, including sign language

all contain critical information that must be decoded with signals. Montgomery's immersive environment of flashing lights that coordinated with brain frequencies was also an experiment. He truthfully admitted a number of people dropped out of participating, exposing the fraught relationships between art, experiment and audience. DIKKER + OOSTRIK dealt with 'pairwise synchrony' in their installations, noting that individuals who are familiar with one another beforehand synch up the best. The purpose of this was to arrive at a clinical application for the diagnosis and treatment of social cognition disorders. The use of data collected from art installations is viewed as more 'real world', because it is crowdsourced from outside the lab. Another bonus of using art in brain research is it results in technological innovation, public education and broader social outreach. In *EEG Kiss* by Karen Lancel, Hermen Maat and Frances Brazier, the question is raised if shared intimate experiences of social touch can be mediated through BCI interaction in public spaces. Their installation includes two participants sharing a kiss while wearing a BCI. They could be partners or strangers, and during the event needed to keep their eyes closed, but could use different motor movements. The visual display of their activity resulted in their embrace being surrounded live time in an undulating corona of light.

Some of the chapters that veer off into evaluation studies and parameter mapping, useful for studying those with disabilities. These inquiries tumble through the rabbit hole of arcane music theory parameters, figuring out the distinction between perceived and induced emotions using alpha or beta brainwaves and metrics. A question raised by all this measuring is, it a type of digital phenotyping? The idea of measuring affect and emotion is complex because it is very difficult to know if non-conscious or unnamed feelings are involved. It depends on the conceptual model, the subject's self-reporting, figuring out what a digital sensor is measuring, and who is determining those measures. Also are these universal or culturally determined experiences, meaning a factor like sameness of the control group could be an issue.

Zakaria Djebbara, Lars Brorson Fich, Klaus Gramann as to a lesser extent Jesus G. Cruz-Garza and his group of authors mix brain dynamics with human movement as a valiant attempt to look at the art/science dichotomy through MoBi or mobile brain dynamics, as well as other processes. They veer off into the highly questionable area of neuroaesthetics or the "perceptual processes of art as realised through the human brain and the visual cortex in particular." When researchers start throwing around terms like 'beauty' anywhere outside of scientific circles they inhabit, they are walking into a conceptual mine field. For example, when graffiti art first emerged it was viewed as vandalism, and a punishable offense. Now, it is seen as beautiful and highly collectible. What changed this definition of beauty? The discussion of beauty and art in terms of the Greeks and Romans is incredibly euro-centric especially in light of the depth of diversity of the different cultures in the art world. The biggest take away distills into the fact you must have a body to experience art. From a scientific point of view, it is a point well taken, but most artists would just roll their eyes at the attempt to make a theory of perceptual experiences based on observed analysis that dilutes millennium of global art history, theory, social contextualisation and material and technological breakthroughs. It boils down to "if we can track it and codify it we can understand artistic secret sauce" which translates into highlighting neuroimaging studies of cognitive and movement-related processes and the brain while looking for a 'universal model of the human creative process'. Starting with Freud, they search for "knowledge and stimuli that is relevant to solve a particular problem." Except here is the secret sauce of the art world

– there is no problem, and the fact that there is no problem shreds the basis of the scientific model of inquiry into tatters. They also posit during an 'aesthetic' experience there is a special cortical neural signal, then use an anorexic European style ballerina in a tutu to represent dance. Those stereotypic and gender representations are a marquee advertisement of high bourgeoisie classical acceptability from the nineteenth century, and are not, surprise surprise, the way art is looked at anymore except through conventional means. Coming to their senses, they ask what does authenticity mean in relation to the creative process, and ponder how to measure it. Their conclusion is 'Creative Art therapy for neuro-rehabilitation', which is where they should have started not ended their argument. Then their whole inquiry would have made much more sense.

Most of these experiments, funded big time by organisation like the National Institute of Health, the National Science Foundation, and the Cullen Foundation support creating a closed loop neurofeedback experience using alpha, delta, theta, beta and gamma waves, though my understanding of delta is that it is most recognisable in sleeping babies. Their research was guided by that old workhorse, the 1924 breakthrough alpha signal. Their data had so much signal processing noise it had to be smoothed out through a Gaussian filter in order to function. At least, the artist collaborator in the experimental group admitted that some of their interactions 'failed outright'. When the book veers into brain art as a special communications technology, and as a therapy stressing the rehabilitative and therapeutic potential of BCIs to reduce anxiety and encourage self-expression, then these chapters make more sense because they refer back to the underlying scientific mandate of using BCIs for art.

Tools, technology and hacking, as well as brain controlled cinema is discussed by Richard Ramchurn and his co-authors as a 'tool to enhance storytelling within cinema', a fertile area for exploration. They discuss Pia Tikka's work *Obsession*, where four screens surround a viewer who was monitored for heart rate and skin conductance changes. This method created a real time feedback loop changing the viewed montage in a process called enactive media. Alexis Kirke's *May Worlds*, a branching narrative story used sensors to measure EKG and other body functions, referred to as neurocinematics. It judges the effectiveness of how much a film controls the viewer's mind by correlating the subjects eye tracking data. This type of research became a real hit with euro-marketers and pre-premier data analytics questionnaires run by movie studios. These same practices also march into the fraught areas of surveillance capitalism, but the authors are thankfully well aware of those tangents.

The final sections on brain painting for those with locked in syndrome or ALS are part of the therapeutic uses of BCIs that use the P300 signal. The sections on BCIs using augmented and virtual reality points the way towards what will become the norm in terms of future gaming devices. The addition of descriptions of the BR4IN.IO hackathons, or 24 hours of pizza, no sleep, no shower and the software programs C#, MATLAB and Java boil down to creating 3D printed objects for assistive technology, a worthy goal indeed, but questionable as art.

As the race to map inner space heats up, the next decade will launch immersive gaming, VR, AI, biometrics, the realisation of Elon Musk's Neuralink, and portable infra-red light-based emulations of fMRIs. It will also launch new start-ups and businesses. These areas are ripe for a second volume that should include a rigorous look at these technologies both within the history of media art, an overview of artistic advances in the past few years, and most of all, the deeply disturbing issues of the ethics and regulation of messing around inside the human brain, including a highly necessary chapter for a call to action.