BABY X:
DIGITAL ARTIFICIAL INTELLIGENCE, COMPUTATIONAL NEUROSCIENCE AND EMPATHETIC INTERACTION

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Abstract

As a new media curator, I work with artistic practices that engage multi-sensory media environments. *Baby X* is a digital artificial intelligence mixed reality installation created by Dr Mark Sagar. It is concurrently a neuro-behavioural computational model with emergent behaviours actively being used for neuro-scientific research and, at times, a media art installation on public display. This paper will explore some of the diverse issues at play in this project from the perspectives of embodied cognition, emotional engagement and perception within a mixed reality environment and trans-disciplinary research context.

Key Words: media art installation, mixed reality, embodied cognition

Fig 1. Sagar, M with Laboratory for Animate Technologies, Auckland Bioengineering Institute, *Baby X* (snapshot), autonomous animation, 2013 (© Mark Sagar).

Introduction

In the Laboratory for Animate Technologies at the Auckland Bioengineering Institute at University of Auckland, Dr Mark Sagar and his team are building a computational model of the brain and face. The model is constructed using current neuro-scientific research sourced through collaboration with the university's Centre for Brain Research.

Sagar has developed a unique aspect of this research project: *Baby X*, a mixed reality installation for display in public settings including museums and galleries. When installed the work, *Baby X*, is essentially an interactive media art installation, containing both scientific and artistic content. *Baby X* invokes a number of challenges to the new media curator in terms of contextualization, presentation and audience engagement. The work traverses a diverse disciplinary territory, it has a complex technical nature, it raises specific debates concerning embodied cognition and neuro-behaviours, it is displayed in both scientific and artistic venues and has a wide and deep collective and specialised research culture supporting its ongoing evolution.

Having come from the animation film and entertainment industries, Sagar's research interests include developing a universal system for mapping faces including morphology, anatomy and biomechanical modeling. Accordingly he analyzed the muscular facial control system and began investigating the emotions and neuro-behaviours driving character expression. This led, in turn, to the current project to create a neuro-behavioural computational model with emergent behaviours.

Baby X as interactive media art installation

In a typical 'media art' installation *Baby X* exists within a standard black box gallery environment. Upon entering the exhibition, the audience sees a large screen on which the face of an animated child is projected, disembodied, larger than life and floating against a black background. This autonomous animation is capable of responsive behaviours through a variety of camera-based sensor tracking systems aimed at monitoring eye and individual body movement of the viewer. The child follows their actions and movements, often engaging through direct gaze, and displaying realistic behaviours such as smiling, crying, confusion and abandonment. The child's character is based on Sagar's own six-month-old baby and is therefore pre-verbal.

Linked to the autonomous child animation, separately screened, is a real-time neural simulation. In a live neural network, representations of muscular anatomy through to the neuronal activity and neuromodulator levels can be viewed. It is possible to follow live stimuli through the responsive neural pathways and through this simulation gain understanding of neural networks. Thus, *Baby X* brings into play an oscillation between character, neurobiological representation and digital artificial intelligence. Digital artificial intelligence in this sense is a simulated virtual biology based on life-like behaviours. Digital artificial intelligence in the case of *Baby X* can be encapsulated, as Shanken has described, as "synthetic biology". [2]

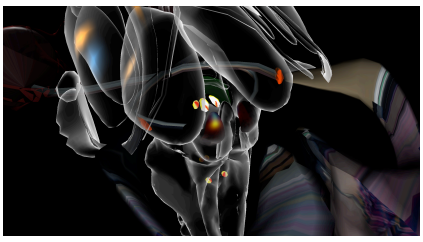

Fig 2. Sagar, M with Laboratory for Animate Technologies, Auckland Bioengineering Institute, *Baby X* (animation still), autonomous animation, 2013. (© Mark Sagar).

Baby X, trans-disciplinary research and collaborative modular construction

In this sense, *Baby X* digitally simulates a synthetic biology through representing neurobiology generated from algorithmic functions. This project is made possible by its trans-disciplinary research basis. *Baby X*, as a work, crosses across disciplinary boundaries, being of interest to the arts, sciences and bioengineering. Mark Sagar as a practitioner is variously artist/animator, designer and bio-engineer.

This trans-disciplinarity is reflected in its design framework. *Baby X* is constructed of 'neural building blocks'. It is built to be both modular and to accommodate the needs and interests of diverse research communities. As Sagar states: "We are building a collaborative modular model of the face and brain, a brain and face Lego with swappable and reshapable parts" [3].

The methodology of neural modular architecture is supported by Grand who proposes that: "Nature, then, seems to work with three fundamental neural architectures to solve the problems of behaviour and control. The first and

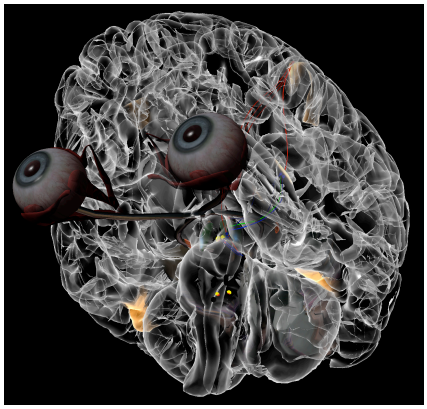

Fig 3. Sagar, M with Laboratory for Animate Technologies, Auckland Bioengineering Institute, *Baby X* (animation still), autonomous animation, 2013 (© Mark Sagar).

Please reference as: [Author(s)-of-paper] (2013) [Title-of-paper] in Cleland, K., Fisher, L. & Harley, R. (Eds.) *Proceedings of the 19th International Symposium of Electronic Art*, ISEA2013, Sydney. http://ses.library.usyd.edu.au/handle/2123/9475
Page numbering begins at 1 at the start of the paper.

simplest is to use the neuron itself as a basic building block in relatively simple networks … The second is to use repeated circuits of neurons, .. as the basic building blocks.' The third neural architecture is a higher-level building block that 'has the capacity to reconfigure itself during the creature's lifetime.' He postulates a fourth, volitional level of brain structure that may control the 'flow of signals around groups of pre-existing self-configured maps in a highly flexible and general-purpose way.'" [4] It is this modulated and fundamentally flexible design and construction premise that is at the base of *Baby X's* computational model.

Fig 4. Sagar, M with Laboratory for Animate Technologies, Auckland Bioengineering Institute, Baby X (animation still), autonomous animation, 2013 (© Mark Sagar).

Recently, Sagar collaborated with Angus Kerr and Rita Soromenho to create an architectural pod to display *Baby X*, and with Murray Fisher to compose sound. The architectural housing expands the emotional and physiological states of the brain through an embedded network of fibre optic cables and LED strips creating a virtual nervous system. Sound, generated live through a synthesizer MIDI system, composed by Fisher and developed by Ricky Huntington, reflects, through major and minor chord changes and tempo, the shifts in state. As Sagar explains, "The idea is to create 'emotional amplification' through simultaneous and correlated expressive modalities (facial behaviour, expression, music and light)." [5]

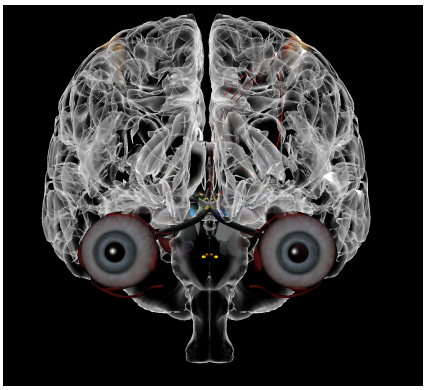

Fig 5. Sagar, M with Laboratory for Animate Technologies, Auckland Bioengineering Institute, Baby X (animation still), autonomous animation, 2013 (© Mark Sagar).

Baby X, empathetic engagement and emergent behaviours

In a recent public exhibition, when *Baby X* was displayed for the first time in the specially designed pod, many of the viewers experienced an empathetic connection to the character. The intensified conditions of exhibition magnifying the brain states caused an emotional and responsive rapport between viewer and character.

With repeated use, the character develops richer and more complex responsive behaviours. At this early stage of development the model already displays emergent behaviours. This aligns with Seaman's definition of neosentience – "The N_S.E.N.T.I.E.N.T. Paradigm' comprising the various characteristics of being Neosentient; Self-organising; Environmentally embedded; Nascent; Temporal; Intra-active; Emergent; Navigational; Transdisciplinary.'

The model could be described as having the capacity to focus 'on the theoretical relations between cognition (top-down processing) and perception (bottom-up processing)". [6]

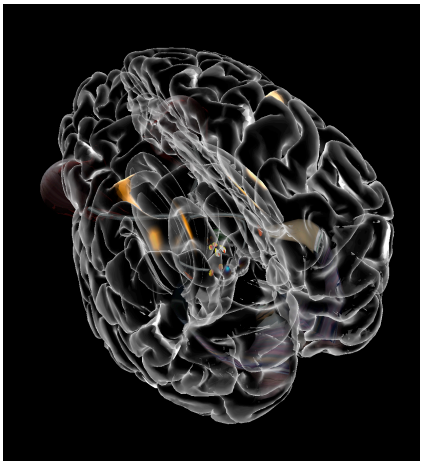

Fig 6. Sagar, M with Laboratory for Animate Technologies, Auckland Bioengineering Institute, Baby X (animation still), autonomous animation, 2013 (© Mark Sagar).

In the act of viewing this mixed reality installation, conditions of cognition and perception from the audience perspective, arise. Like many media art installations, *Baby X* contains both virtual and real elements. Existing within a mapped space monitored by sensors, *Baby X* requires the viewer to engage with the character in order to enact the process of viewing. As Kathy Cleland states: "We are now living in a mixed reality paradigm where the real and the virtual, the natural and the artificial blend and intermingle in complex ways" [7]. The combination of real-time interaction, immersive conditions of viewing and the character's frequent direct gaze result in an installation that is emotionally engaging.

Additionally, this replicates recent neuro-scientific research regarding mirror neurons. "Experiments show that areas of the brain collectively known as the mirror neuron system respond not only when individuals perform and action themselves but also when they watch someone else perform that action … Similarly watching someone cry, being hit or expressing emotion can trigger empathetic mirror neuron responses so that those actions and responses are experienced by the person watching." [8]

In the real-time of media installations, the audience, in the act of experiencing and discovering the installation through sensing, movement and feeling, develops understanding through assimilating the space of the installation, the body and the mind. Mixed reality installations require embodied cognition. [9] As Chris Salter observes: " … perception is not representation but action – a direct projection of the body into the environment and an ongoing 'probing' of that environment with the sensor and motor capabilities of the active body." [10] *Baby X* is a curious work as it activates an exchange between viewer and virtual, 'probing', surface and varying degrees of micro layers, reciprocal emotion and gesture. Through the virtual and actual interrogation of interaction and perception in the process of experiencing the work, an interesting dialogue between cognitive neuroscience, computational neuroscience and embodied cognition emerges for the viewer.

Baby X as scientific research tool

As mentioned earlier, *Baby X* is also a scientific research tool. The Laboratory

for Animate Technologies is part of the larger Centre for Brain Research at the University of Auckland. Current research within this centre involves over 40 research teams and more than 200 researchers deployed across the university. Each research team specializes in one of four areas – clinical neuroscience, cognitive and computational neuroscience, molecular and cellular neuroscience and sensory and motor neuroscience. The Laboratory for Animate Technologies is located within the cognitive and computational neuroscience research strand.

In terms of disciplines, this collaborative computational modelling research initiative involves staff and students from computer science, architecture, neuroscience, engineering, psychology and the arts. It is in essence a trans-disciplinary research project integrating various disciplines, processes, perspectives and frameworks and is actively creating new understandings as a result.

This can be seen in the overall computational neuroscience research project that is currently exploring both theories of brain function and brain disorder. For example the effects of synthetic lesions or damage to key circuits due to conditions such as Huntington's or Parkinson's disease can be visualized both schematically and also in the way they affect the animation of the computational modelling that is an aspect of *Baby X*.

Applications for the computational model range far beyond medical research parameters and extend to commercial applications including gaming and film markets. In the entertainment industries, there is an increase in demand for realism and a desire to automate elements of the animation process and to create fully autonomous characters. These applications require a particular focus on facial features in terms of developing a dynamic character that includes capabilities of communication, identity, emotion and intent. Consequently the Auckland Face Simulator project, led by Mark Sagar with an investigative research team comprising of Associate Professor Paul Corballis, Dr Benjamin Thompson and Dr Jason Turuwhenua, was established. Research has been initiated where experiments involving animation, psychology and visual neuroscience are underway.

Baby X is a complex work intertwining and challenging disciplinary boundaries within rich scientific and artistic contexts. As a computational model with emergent behaviours it raises interesting content for analysing our relationships between the virtual and the real. As a computational neuro-scientific project it facilitates an ongoing analysis of emotional, sensing and perceptual functions of a simulated brain. As a project that has an ongoing development and research programme, it has particularly curious applications and possibilities for future experimentation. In its immersive media installation context, it enables a potent dialogue between embodied cognition and simulated computational neuroscience. In addition, the amplification of the emotional intensity of the work, through design, causes an empathetic audience interaction with the autonomous animated character and vice versa. This expanded context generates a complex territory for facilitation, research and curatorial practice.

References and Notes

1. Observations, contained in this paper *Baby X*, form the basis of a Doctorate within the College of Fine Arts, University of New South Wales and the National Institute of Creative Industries, University of Auckland. The creative practice component includes formation of a trans-disciplinary research group and staging exhibitions and symposia from 2014-2016. I acknowledge the support of the University of New South Wales and the College of Fine Arts.

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