DIY DNA VISUALIZATION: A PRELIMINARY METHOD

Rebecca Clunn, 18 Jenkinson St,
Indooroopilly, QLD 4068 Australia
E-mail: rebeccaclunn@live.com.au

Abstract

The findings presented in this paper are the result of research from the work "ONE: a durational performance by Rebecca Cunningham and all of you" wherein the artist creates a bio-portrait and symphony from the DNA of one million strangers. A preliminary DIY method undertaken by the author will be followed by a discussion of the particular practical, technical and legal implications for the large scale collecting and imaging of human DNA. The paper concludes with areas of future research and further questions.
www.oneperformance.wordpress.com

Keywords: performance art, DNA, DIYbio, visualization, large data, portraiture

Introduction

"ONE: a durational performance by Rebecca Cunningham and all of you" is a performance that may take ONE lifetime. ONE person, sitting opposite ONE person. There is ONE exchange. ONE sample of DNA is collected. If desired ONE sample of DNA is exchanged. This will happen ONE million times until ONE million samples have been collected. Once ONE million samples from ONE million people have been collected, each DNA sample will be imaged. From ONE million DNA images ONE will be made, a composite of all becoming ONE [1]. This paper outlines the research from the work "ONE". A preliminary DIY method undertaken by the artist-author will be followed by a discussion of the particular practical, technical and legal implications for the large scale collecting and imaging of human DNA. The paper concludes with a discussion of areas of future research and further questions.

Fig. 1. Rebecca Cunningham - ONE premiere Brisbane Festival Under the Radar 2011. (© Rebecca Cunningham. Image Gerwyn Davis)

Bio Art is a burgeoning field with artists such as Stelarc [2], Andre Brodyk [3], Svenja Kratz [4] and Terumi Narushima [5] pioneering the field. Further, bio focused institutions and organisations such as La Paillasse [6], and DIY BIO [7] are emerging worldwide.

ONE began in 2010 as an idea. I will now continue this work for the rest of my life. I was thinking about trust, and community. I was wondering what it would look like if we could get the smallest parts of ourselves and put them as close together as possible. What would this mean? What would this look like? Would it be interesting?

ONE consists of three components 1) DNA Collection 2) DNA Visualisation and 3) Translation of Visualisation into sound. Each step will be further elaborated in turn.

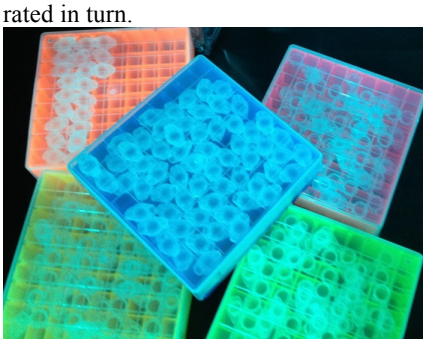

Fig. 2. Eppendorf tubes (© Rebecca Cunningham.)

1) DNA Collection

This component consists of a performative act between myself and one million individuals. This process as performance was premiered at the Brisbane festival in 2011 and has since been performed in New York, Paris and multiple sites in the United Kingdom and Australia.

2) DIY DNA Visualization

Three steps have been identified for the DIY DNA visualization of a human hair sample: a) extraction, b) amplification c) visualization. The following is a preliminary protocol.

Step a – DNA Extraction

Fortunately there are existing protocols for the extraction of DNA from human hair [8]. Put simply, 10-15 roots are cut approx 0.5cm long and put into a 1.5ml eppendorf tube. 50ul of 200mM NaOH solution is added. The tube is put into a water bath of 94 degrees Celsius for 10 minutes. The sample is cooled at room temperature to which is added 50uk of a solution containing 200mM HCL and

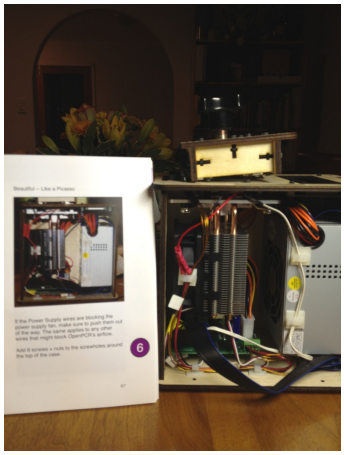

Fig. 3. Building OpenPCR (©Rebecca Cunningham.)

100mM Tris-HCL having pH 8.5
After this is completed, the sample is ready for amplification.

Step b – DNA Amplification

Traditionally PCR – Polymerase Chain Reaction has been used to multiply a sequence of DNA many millions of times; making visualization possible.

The initial issue with this method was that PCR machines – thermal cyclers – have been very expensive and accessible only through professional laboratories. In the twenty-first century and with the advent of BIO hacking and open source, the DIY bio community have created open source PCR. There are two companies which offer PCR kits, Lava Amp [9] and Open PCR [10].

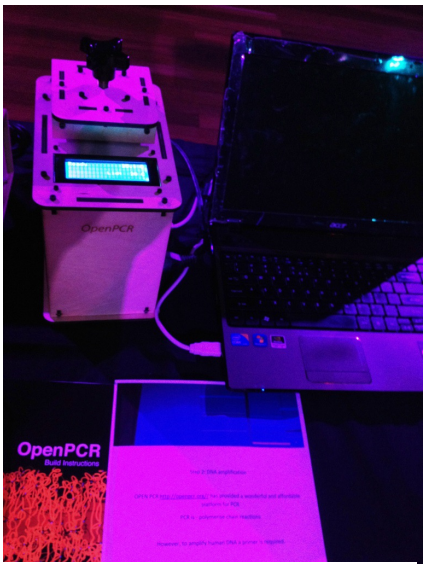

Fig. 4. Running Open PCR (©Rebecca Cunningham.)

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.

The Open PCR kit comes with software that connects simply to your laptop. The extracted sample is then taken and a primer added. The primer specifies which part of the DNA strand the PCR is to amplify [11]. As this process is designed to create images of the DNA rather than to genotype or sequence the DNA, this lo-fi method is currently suitable. The type of primer used will also have an impact on the process run on the PCR. Once the primer has been added to the extracted sample it is placed into the PCR. Within the PCR process the samples are heated and cooled at specific times and temperatures. After approximately three hours the samples have run through this process and are ready for visualization.

Step c – DNA Visualization Gel Electrophoresis.
There are a range of possibilities for DNA visualization such as Scanning Electron Microscopy, Transmission Electron Microscopy and gel electrophoresis. The method of visualisation is selected based on what type of analysis is required [12, 13]. As this project is not analyzing, sequencing or genotyping the DNA sample, yet simply imaging for the sake of a "do-it-yourself" or DIY setting, gel electrophoresis has been selected [14]. To undertake gel electrophoresis, one requires a gel electrophoresis chamber and low voltage power supply, in addition to other ingredients such as buffer, chemical grade agarose, and dyes [15]. The first step is to create the gel, which is made with chemical grade agarose and dye. The dye is required so that the DNA will be visible. The common dye used is ethidium bromide (EtBr), however, this dye is a known mutagen and is not safe to use in a DIY setting. SYBR Safe is another option, however as yet I have been unable to source this chemical in Australia. SYBR Green is a commonly used dye in gel electrophoresis and it does bond to the DNA particulates. However as SYBR Green is a known carcinogen, it is prohibitive in some DIY scenarios [16].

Once the gel is made with the dye, it is set with a comb. Once the gel is set, the comb is removed, allowing divots to be revealed in the gel. This is then placed into the gel electrophoresis chamber. The chamber is filled with buffer with a ph8.4 – akin to seawater. The samples from the PCR are loaded into the gel via a pipette. Low and varied levels of voltage is applied to the chamber. This pushes the DNA through the gel as small pieces of DNA move faster than large pieces of DNA. This process may take between eight and twelve hours. Once the gel has completed its run, it is removed from the chamber and placed on a dark reader [17]. This device pushes blue Ultra Violet light through the gel, illuminating each sample, making the DNA "pop" wherever it has stopped in the gel. A dark room and safety glasses must be used for this process.

Fig. 6. Dark Reader (©Rebecca Cunningham)

3) Translation of Visualisation into sound.
A future component of this work involves translating the image of an individuals' DNA in sound. During the residency at The Edge, and further, while touring ONE in Europe last year, I began searching for established procedures for this translation [consisting of translating the colour spectrum to the sound spectrum and bringing the pitches into the human audible realm]. There are some open source ware that allows for this to happen in a routine and mechanical way. Working alongside a programmer would allow for this component to be developed, and ultimately a piece of freeware that elegantly reads images will be developed and released.

Participant experience and feedback
Relating this process back to the work ONE, the participant's first experience of the work takes place during the performative collection process. To date, there have been over 150 participants. In the majority of cases, the performative setting is public such as in a museum, a mall, or a foyer. I sit in a lab coat at a table with one chair empty. I have a secure box, a series of analogue rubber stamps and a carbon paper book set out on the paper. On the chair there are instructions "If this chair is free, feel free to sit with me." I do not ask people to join me outside of this textual invitation. Once a participant sits with me, I invite them to read some text about the work [the same as that outlined in the introduction to this paper]. I ask if they have any questions. At this point, the conversation turns any number of ways. Frequent questions include, what are you going to do with my DNA; what type of DNA are you collecting; are you a scientist; and what do you think this will look like. Often the conversation turns to policy, current genomic trends and ethics.

Once I feel that the conversation has come to a natural pause, I ask if the participant if at this time they would like to participate in this artwork. If a participant indicates they would not like to participate, they are thanked for their time, and given the link to the website for the project should they reconsider. Participants who choose to participate are then asked to read the template participant authorization statement. We then complete the statement together, and exchange a hair sample, carefully putting ten strands of hair into a zip-locked bag with the participant's number. At this point the performance element ends and the participant leaves the performance space.

Participants may at any stage contact me with questions or queries related to their participation. After the initial interactions and exchange, I do not contact participants until their DNA has been visualized. Once this has occurred, each participant receives a copy of their DNA via email. Once the image of their DNA has been converted into sound, participants then receive a sound track of the image of their DNA. The individual images are then compressed and compiled until there are one million people's DNA visualized as a single image and sounds compiled into a symphony.

Technical and Legal implications
Space: Although the process is planned to be DIY, due to the chemicals used there is a technical requirement to have a clean bench lab space. I am working to make a clean bench so that I may run samples at my leisure. Prior to this I plan to use a lab to practice and refine my skills on a pilot batch of samples prior to

commencing imaging on ONE samples proper.

Cost: The cost of imaging each sample is approximately $50AUD per person with the outlined method. The initial outlay for the PCR machine, gel electrophoresis chamber, low voltage supply and dark reader were under $5,000 AUD, however the ongoing cost of consumable chemicals and primers are significant. For DIY DNA visualization to become feasible in any large quantity, inexpensive alternatives will need to be developed.

DNA regions and Ethics: We know that human DNA is mostly the same and we have many aspects in common with other species. As the outlined method looks at a particular sequence rather than the whole DNA strand, the outcome of the image is likely to be rather pedestrian and uniform. A more interesting approach might involve imaging non-coded/regulatory/junk DNA that has variation in length. Coded DNA is represented by approximately 5% of our sequence with non-coded/regulatory or junk DNA comprising the remaining 95%.

There are two obstacles to pursuing this option of exploring non-coded DNA regions. First, a primer will need to be designed and created to amplify this non-coded DNA sequence. The project ENCODE will be an important resource in the initial stages of design. I am not a scientist nor geneticists, so much more research and collaboration will be required to pursue this primer design and implementation [18].

Second, there are considerable ethical and legal implications when looking at non-coded DNA regions. In 1989, the Australian company Genetic Technologies was formed, and soon after it was successful in its application to patent all non-coded DNA in humans and animals [19]. Any person or researcher wanting to investigate non-coded DNA must now request a license from Genetic Technologies Ltd [20, 21].

I have been asked why I wish to undertake this laborious lab work when there are outsourcing potentials with companies such as 23andme [22]. It is true that there are better, more efficient ways to do this. However, I consider this work conceptually as an experiment in trust - strangers trust me with their DNA and I trust them with mine. At the point of exchange, I say that only I access the sample. If that changes I promise to contact them and request their permission. As this is part of their body I want them to have control over these types of decisions. I appreciate how laborious this makes the work, but I think it is worth it. I want to be intimate in this way, working with the DNA of 1 million people over the course of my life. As such, I don't want to outsource the labour as I feel this undermines that foundation of trust that I aim to build within the exchange. Although this work has an end result, the image and symphony, this work will continually evolve as I progress through my life. In time, technology will change, thus these processes will change and in turn, the work will continue to develop over time.

I am interested in the notion and practice of the organization DIY bio [23], as the scientific lab no longer belongs solely to those with specific training, but is available also to interested and vested parties within the general public. To quote from the organization's website "DIYbio.org was founded in 2008 with the mission of establishing a vibrant, productive and safe community of DIY biologists. Central to our mission is the belief that biotechnology and greater public understanding about it has the potential to benefit everyone" [24].

This ethos of knowledge belonging to everyone is by no means new, however when it comes to DNA and ownership as per the example above (Genetics Technologies), there are many ethical grey areas in this burgeoning field of bioscience and specifically genetics. There are growing banks of DNA samples, such as 23andme, The National Human Genome Research Institute [25] and deCODE (including the famous Icelandic sample) [26]. In Australia there is a swathe of regulatory bodies who legislate around new technologies and advancements [27]. In my experience, DIY bio works within a grey area. As an artist working in this space I feel it is imperative to maintain transparency of practice, just as it is important to maintain the privacy and anonymity of participants.

Conclusions and Future Research

In conclusion, as a lifelong durational work, this artwork ONE will always be changing. There is a need for further research and publications of various elements of DIY bio strategies and procedures both artists and the general public are undertaking in their studios and in their homes. As new technologies become more freely available to the general public, the work will progress at a more rapid rate. I urge researchers to engage further in this field, and I look forward to learning and sharing this process not only with participants, but those interested in DIY bio in general.
For more information, papers, and updates, follow the project at www.oneperformance.wordpress.com

References and Notes

1. www.oneperformance.wordpress.com ONE brief history: 1) DNA collection. This work premiered at the Brisbane festival in 2011. Technical set up requires one table, and two chairs. The artist sits and talks with participants one on one. After discussing the project, the artist and participant exchange DNA. Currently the DNA is a hair sample. An analogue document of agreement is then created by the two parties so that the DNA may be held and imaged by the artist. 2) DNA Visualisation: In April – June 2012, I undertook a residency at the Queensland State Library | The Edge, and here compiled a preliminary method for DIY DNA Visualisation. This method was presented at the CSIRO SPECTRA conference in Canberra [Oct 2010] and at TEDX in Nottingham UK [Nov 2012]. I have been working on the DIY DNA Visualization method, to date, however outside a lecture on DIY DNA Visualizations; - no images have been created nor displayed. I plan to work with a genomic consultant to realize this element. 3) Translation of DNA into sound. All elements are in the process of being realized and presented.

2. Zurbrugg, N "Virilio, Sterlac and 'Terminal technoculture" Theory Culture & Society **16** (1999 p177-199)

3. http://intraactionart.com/andre-brodyk

4. http://svenjakratz.com

5. Fargher, C. Anne . & Narushima, T. "Knit two together: Art/Science collaborations in BioHome: the Chromosome Knitting Project." The Scientific Imaginary in Visual Culture. Ed.A. M. Smelik. Goettingen: V & R Unipress, 2010, 181-194.

6. http://www.lapaillasse.org/

7. www.diybio.org

8. http://www.protocol-online.org/biology-forums/posts/760.html

9. http://lava-amp.com

10. http://openpcr.org

11. http://ghr.nlm.nih.gov/glossary=primer

12. Müller-Reichert, T. Gross, H "Microscopic analysis of DNA and DNA-protein assembly by transmission electron microscopy, scanning tunneling miscroscopy and scanning force microscopy" *Scanning Microscoy* **10**(1996 pp 11-20)

13. Bell, D.C., W.K Thomas, K.M. Murtagh, C.A. Dionne, A.C, Graham, J.E. Anderson, and W.R Glover, "DNA base identification by electron microscopy." *Microscopy and Microanalysis* **18(05)** (2012 pp 1049 – 1053)

14. http://www.dnalc.org/resources/animations/gelelectrophoresis.html

15. I managed to find both of these items on eBay for less than $200.

16. This dye requires a minimum of a clean bench or level 1 lab safety space. SYBR Green must be stored in a refrigerated environment and to remove SYBR Green it must be subjected to activated charcoal and disposed of as solid chemical waste. This dye is also quite expensive for DIY purposes, costing approx $600 AUD for 5 mls.

17. *www.biosci.com.au/* The pictured mini Dark Reader was purchased from Bio Scientific for $700 AUD.

18. In 2007, after the Human Genome was sequenced the Encyclopedia of DNA Elements or the ENCODE project commenced.
http://genome.ucsc.edu/ENCODE/

19. United States Patent number 5,612,179 ('179)

20.http://wwwgtglabs.com.au/announcements/genetic-technologies-us-patent-update

21.
http:/www.patentlens.net/daisy/junkDNA/681.html

22. www.23andme.com

23. http://DIYbio.org

24. http://DIYbio.org

25. National Human Genome Research Institute
http://www.genome.gov

26. www.decode.com

27. Gene Technology Regulations
http://www.ogtr.gov.au/internet/ogtr/publishing.nsf/Content/legislation-2
There are techniques that are not considered to be gene technology and as such I have not sought permission for my artwork
http://www.comlaw.gov.au/Details/F2011C00732/Html/Text#_Toc302474507
The following extracts from the legislation are those found pertinent to ONE "Part 2: Interpretation and general operation
4 Techniques not constituting gene technology
For paragraph (c) of the definition of ***gene technology*** in section 10 of the Act, gene technology does not include a technique mentioned in Schedule 1A.
"
Further looking to section 10 of the Gene Technology Act and Schedule 1A [looking at the current act for Queensland as of July 2013, it refers to itself as Schedule 3
http://www.legislation.qld.gov.au/LEGISLTN/CURRENT/G/GeneTechA01.pdf
the definition of gene technology as per pg 132
" gene technology means any technique for modifying genes or other genetic material, but does not include the following -
(a) sexual reproduction;
(b) homologous recombination;
(c) any other technique prescribed under a regulation for this paragraph
"
In ONE I do not modifying genes, I am imaging them and as such I have not undertaken licensing. However I have discussed this work at length with both Arts Law and the Law Society of QLD and although thinking the project was weird, considering the nature and the content of the work at this stage, licensing was not considered a legal issue.