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ESCOLA DAS ARTES
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BIOFEEDBACK AS AN INTERFACE TO CREATE MATERIALS FOR STOP-MOTION CINEMA

Dissertation presented to the Catholic University of Portugal

for obtaining the Master's degree in Sound and Image

Ema Vitória Fonseca Lavrador

Oporto, July 2023

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"Finally, transformed into tiny quivering photons, each of our deeds will set off into Outer Space, where the planets will keep watching it like a film until the end of the world."

- Olga Tokarczuk [1]

[1] Tokarczuk, O. (2019). Drive Your Plow Over the Bones of the Dead: A Novel (A. Lloyd-Jones, Trans.). New York: Riverhead Books, p. 43.

Abstract

This dissertation explores the potential of biofeedback as an interface for creating materials in stop-motion cinema, also exploring the aesthetic and narrative advantages of incorporating biofeedback technologies and interfaces in animation cinema. The study focuses on the intersection between art created by biofeedback interfaces and the materiality of animation, with particular emphasis on vision-touch synaesthesia and haptic visuality.

The main objective of this dissertation is to explore how biofeedback interfaces can be used to collect data from the human body and adapt materials for use in animation cinema, specifically in the context of stop-motion animation. Through the analysis of case studies involving animation films with haptic visuality and works of art that use biofeedback to create materials, we seek to establish connections between these works and their haptic and kinaesthetic elements and bodily experiences.

The findings of this project reveal that biofeedback technology, and its ability to translate biological information into graphic and three-dimensional signals, present an opportunity to bridge the gap between the animator's body, the viewer's body, and the animated makings. By incorporating biofeedback as an interface, animation creators can go beyond the superficial sensations and perceptions of the viewer's body, thus creating a more immersive and engaging cinematic experience.

This exploration opens up new possibilities for integrating haptic elements through technological interfaces into animation cinema, leading to heightened aesthetic and narrative dimensions.

Keywords: Animation cinema, Biofeedback interfaces, Haptic visuality, Stop-motion, Vision-touch synaesthesia.

Resumo

Esta dissertação explora o potencial do *biofeedback* como interface para a criação de materiais no cinema *stop-motion*, explorando também as vantagens estéticas e narrativas da incorporação de tecnologias e interfaces de *biofeedback* no cinema de animação. O estudo centra-se na interseção entre a arte criada por interfaces de *biofeedback* e a materialidade da animação, com particular ênfase na sinestesia visão-toque e na visualidade háptica.

O principal objetivo desta dissertação é explorar como as interfaces de *biofeedback* podem ser usadas para coletar dados do corpo humano e adaptar materiais para uso em cinema de animação, especificamente no contexto da animação *stop-motion*. Por meio da análise de estudos de caso envolvendo filmes de animação com visualidade háptica e obras de arte que utilizam *biofeedback* para criar materiais, procuramos estabelecer ligações entre essas obras e seus elementos hápticos e cinestésicos e experiências corporais.

As descobertas deste projeto revelam que a tecnologia de *biofeedback* e sua capacidade de traduzir informações biológicas em sinais gráficos e tridimensionais apresentam uma oportunidade de preencher o espaço entre o corpo do animador, o corpo do espectador e conteúdos animados. Ao incorporar o *biofeedback* enquanto interface, os criadores de animação podem ir além das sensações e perceções superficiais do corpo do espectador, possibilitando uma experiência cinematográfica mais envolvente e imersiva.

Esta exploração abre possibilidades para formas inovadoras de integração de elementos hápticos por meio de interfaces tecnológicas no cinema de animação, levando a novas dimensões estéticas e narrativas elevadas.

Palavras-chave: Cinema de animação, Interfaces de *biofeedback*, Sinestesia visão-toque, *Stop-motion*, Visualidade háptica.

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II. List of Abbreviations

2D - two-dimensionality

3D - three-dimensionality

4D - four-dimensionality

CGI - Computer Generated Imagery

DIY - Do it yourself

EEG - electroencephalogram

EMG - electomyography

HR - heart rate

HRV - heart rate variability

MRI - Magnetic Resonance Imagery

QEEG - multi-site quantitative EEG

RSA - respiratory sinus arrhythmia

RTUS - real-time ultrasound imaging

III. Glossary

EEG or **electroencephalogram** - A test that detects electrical activity in the brain using small, flat metal discs (electrodes) attached to the scalp.

Electrogoniometry - A device used to measure angles of joints and their range of motion.

EMG or **electromyography** - A method that measures muscle response or electrical activity in response to a nerve's stimulation of the muscle.

Force plates - Mechanical sensing systems designed to measure the ground reaction forces and moments involved in human movements.

HR or **heart rate** - The number of times the heart beats per minute.

HRV or **heart rate variability** - The fluctuation in the amount of time between heartbeats.

Inertial sensors - Sensors used to transduce inertial force into measurable electrical signals, allowing measurement of acceleration, inclination, and vibration of an object.

MRI or **Magnetic Resonance Imagery** – A non-invasive imaging technology that produces detailed three-dimensional anatomical images.

QEEG or **multi-site quantitative EEG** - A field concerned with the numerical analysis of electroencephalography (EEG) data and associated behavioral correlates.

RSA or **respiratory sinus arrhythmia** – Heart rate variability in synchrony with respiration, by which the R-R interval on an ECG is shortened during inspiration and prolonged during expiration.

RTUS or **real-time ultrasound imaging** - A technique that uses high-frequency ultrasonic waves to visualize internal structures of an organism in real time.

Tokens - Physical visualizations of data, representing one of the earliest forms of data representation.

1 Introduction

1.1 Inspiration and Context

The present dissertation project builds upon my studies in animation cinema, which I pursued during my Master's degree in Computer Animation at the Escola das Artes, Universidade Católica Portuguesa. Throughout my academic journey, I have been fascinated by the impact that our bodies have on art. Over the past two years, as a collaborating researcher at CITAR (Research Center for Science and Technology of the Arts), I have dedicated my efforts to further delve into this topic, as evidenced by my publications and conference presentations.

Beyond the exploration of the body-art relationship, my research interests also encompass spectatorship and the influence of cinema on the audience. I have published a chapter addressing these aspects, particularly in the context of Portuguese cinema during the pandemic[2], and moderated sessions for the Beast International Film Festival, where I engaged with different audiences and moderated conversations on Ukrainian cinema before and after the war in the country.

Body expression and spectatorship have been integral to my artistic practice from the beginning of my academic training. Works such as “Land in Sight” (2022), an autobiographical documentary about my experience as a director with visual impairments due to Multiple Sclerosis, and the interactive installation “Máquina Inútil (Useless Machine)” (2022), a sculpture which expresses different religious symbologies activated by touch, reflect my ongoing interest in these themes.

The idea for this dissertation emerged from a challenge posed by Professor Ekaterina Smirnova in response to a call for papers for Ars Eletronica. While writing the article "Motion capture as a tool of empowerment for female main characters"[3], I became captivated by the synaesthetic interplay between the body and the machine in animation. Given the vast aesthetic and narrative possibilities inherent in this subject, I have chosen to focus my research on it within the scope of this dissertation, while continuing to delve

[2]Lavrador, E., & Teixeira, L. (2021). The impact of lockdown on the exhibition of portuguese cinema: study of the display, distribution and audience during the Covid-19 pandemic. In La representación audiovisual de la ciencia en el entorno digital (pp. 139-152). McGraw Hill España.

[3] Lavrador, E., Teixeira, L., & Kunz, S. (2022). Motion Capture as a Tool of Empowerment for Female Main Characters. In International Conference on ArtsIT, Interactivity and Game Creation (pp. 504-514). Cham: Springer Nature Switzerland.

into the theme of the Ars Eletronica Synaesthetic Syntax: Gestures of Resistance conference that motivated me to deepen my knowledge concerning biofeedback.

I hope that my study will be a valuable resource for future artists and academics working in the areas that I address. The following chapters provide an in-depth exploration of this topic.

1.2 Research Purpose and Goals

In this dissertation, our primary goal is to explore the potential of biofeedback interfaces[4] in gathering data from the human body to adapt materials for use in animation cinema, particularly in stop-motion animation[5]. Our research has unveiled that various works of art, such as "Vision" by Carol Steen (1996), "At the Threshold" by Daria Martin (2015), and "Six-Forty by Four-Eighty" by Zigelbaum + Coelho (2010), employ biofeedback to develop images. Our study aims to focus on the potential of this interactive technology to create tangible materials that tell stories. This inquiry arose from our fascination with vision-touch synaesthesia, wherein a visual sensation produces a bodily impression upon observing an image. As such, we plan to begin our dissertation by contextualizing biofeedback and its varied applications in the arts. Next, we will explore our theory of how vision-touch synaesthesia can profound narrative and aesthetic significance to stop-motion animation. Finally, we will present a series of artistic case studies that support our theory.

Throughout our examination of case studies, we will examine animation films that feature haptic visuality[6] and works of art that use biofeedback to produce materials. We will relate these works and their haptic element to the combination of kinaesthetic and bodily experience. Given its ability to harmonize sensations, we have chosen to theorize the relationship between the haptic and the technological means of biofeedback by introducing new concepts that challenge the viewer's perception of vision and touch. Our

[4] Technology that we consider, following the definition of Gartha (1976), to be the process of reading physiological signals and translating them to an observer, and this term applies to all instruments that provide instant information and apply it.

[5] According to Maselli (2018), we understand that stop-motion is an animation technique that provides the illusion of movement when photographed frames are viewed sequentially.

[6] According to Marks (1998) haptic visuality differs from optical visuality because it happens when the body is involved in the observation process.

research will also highlight how materials can be produced based on the data collected by the user through biofeedback, which we will describe as a data translation interface. Finally, we will discuss the artistic presentation of the results.

Our research aspires to develop an innovative approach by confronting the areas addressed, with the aspiration that our discoveries will benefit both the artistic and scientific communities. We believe that biofeedback can unlock new possibilities for stop-motion animation, allowing animation filmmakers to create novel performative techniques that invite the audience to participate in an interactive experience. This new mode of filmmaking expands the characteristics of animation cinema through new media, paving the way for innovative forms of representation.

1.3 Research Structure

The primary objective of Chapter 2 is to introduce biofeedback as a technology that translates biological signals into computer-generated information, serving as a data translation interface. Based on this concept we can state that this translation, when applied to the artistic modeling and creation of materials, can provide objects with a new narrative and aesthetic potential. Since biofeedback is an interactive medium with several capabilities, our concern is to understand how this technology directed to the visual arts can influence the audience, enhance the tactile reception characteristic of objects and increase participation in the work.

Through this chapter, we will investigate the relevance of physical visualization of biosignals in the artistic field and examine whether biofeedback technology can enhance works with aesthetic and conceptual meaning while aligning with the principles of interactive artworks.

As information can be presented in different ways, we will particularly explore the awareness insights of physical graphical models, firstly because it is an under-researched format that offers multiple artistic interpretations, and secondly because we want to highlight the reception of medical data through tactile senses and assess whether this materialization makes the information more accessible for understanding.

The objective of Chapter 3 is to define vision-touch synaesthesia and how it is expressed in different art forms. We will examine case studies from literature, art, and

moving image that utilize this type of synaesthesia to evoke emotions and impact the spectator.

To begin, we will define synaesthesia and its classifications, both as a pathology and a metaphor, considering that this marker is what separates the synaesthetic experience of non-synaesthetes from synaesthetes. Next, we will delve into touch-vision synaesthesia to analyze its use in literature, art, and moving image. By distinguishing synaesthetes and non-synaesthetes, we intend to identify the essential characteristics that stimulate synaesthesia by vision-touch. Here, we will study pathological synaesthesia to understand its influences on sensory comprehension and expressions of tactility to identify the key features that induce synaesthesia in non-synaesthetes.

Chapter 4 serves to introduce the reader to the principles of animation and the representational capacity of the medium. We seek to contextualize our interest in the relationship between the narrative and aesthetic of animation cinema. Additionally, we will present a practical exercise designed for school students and share our observations, relating this practice to theories about materiality and interpretation, focusing not only on the spectator's perspective but also on the creator's viewpoint.

The purpose of Chapter 5 is to examine the impact of synaesthesia on stop-motion animation, a technique that operates physical materials to create visual outcomes and its effect on the visual and tactile perception of the audience. Starting with a historical overview of synaesthesia in animation, spanning from early 20th-century experiments to contemporary cinema, we will examine case studies of experimental, documentary, and fictional films, including both short and feature-length works, to explore how synaesthetic qualities influence the narrative, diegetically and non-diegetically, and the viewer's experience.

Furthermore, we will delve into the concept of stop motion cinema and its evolution over time, encompassing analog to digital manipulation procedures, to showcase the diversity of productions made employing this technique, always giving relevance to films with higher tactile qualities.

Lastly, in chapter 6, we will expand our hypothesis in this dissertation by pointing out animated films that use biological signs and anatomical elements and films that use explicit medical images, to continue the appeal for the creation of an animated film with three-dimensional elements through biofeedback interfaces.

1.4 Methodology

We aim to develop an argument regarding the relationship between art generated by biofeedback and synaesthesia in stop-motion animation. Our goal is to explore how materials created through biofeedback can contribute to new aesthetic and narrative meanings in animation cinema.

Following Creswell's (2021) methodological theory, we will employ a qualitative research design to incorporate case studies. We have chosen a qualitative approach as it is better suited for proving our theory, and case studies provide a practical means of testing hypotheses and establishing standards.

The research methods will be qualitative, based on interpretation of patterns and study of texts and images. Through qualitative methods, we seek to establish relationships between different areas to observe the audio-visual specificities and perceive the synaesthetic pattern across different art forms. Additionally, we plan to conduct a brief workshop with children aged 12 to 14 to gain their insights into stop-motion animation and evaluate the ease of interpreting the results.

The central research question of this dissertation is "Can biofeedback serve as a medium for creating materials in stop-motion animation?". Our interest in this specific synaesthesia stems from its potential application in the aesthetic and narrative construction of stop-motion animation, a frame-by-frame[7] cinematographic technique that involves working with physical materials. We intend to establish a relationship between these topics and biofeedback technology, which is a medium that enables the creation of materials through active participation.

In addition to providing an artistic and technological context for biofeedback, we will reflect on the haptic element of stop-motion animation, also called “haptic visibility" by Marks (1998), which challenges the viewer's tactile and visual perception. Our objective is to prove that the relationship between animation cinema, biofeedback, and haptic visuality can result in an innovative synaesthetic experience.

[7] A frame is the basic unit of the moving image, corresponding to a photogram of the sequence of images. Frame-by-frame is an animation process in which individual frames are slightly manipulated to give the sequence the illusion of movement (Beaver, 2006).

We believe that our project is significant due to the scarcity of literature on the utilization of biofeedback for material creation, the exploration of synaesthesia in stop-motion animation cinema, and the use of biofeedback as a medium for animation. The selection of case studies will be based on their specific characteristics, aiming to illustrate or substantiate the literary analysis. We will prioritize globally accessible works, such as digital art or installations with online information and videos, as films that enjoy greater visibility and easier access.

2 Tactile Art and Biofeedback: Biofeedback as a Data Translation Interface for Physical Artistic Outputs

2.1 Introduction to Interaction and Digital Art

Interactivity, as a practice, has been recognized as a genre that has evolved since the 1950s, due to advances in fields such as Artificial Intelligence, HCI (Human-Computer Interfaces), and Computational aesthetics. Within this genre, digital artists still debate about the aesthetic importance of interactive works. According to Boden (2005), because the audience can interact with the piece, the visual or musical aspects can be seen as less relevant compared to other traditional art forms until then. In this medium, artists can enhance different results depending on the interaction of the public. Some artists defend that the changes that take place in interfaces must be noticeable for the public to understand that they are influencing the behaviour of the artwork, while other artists advocate for discrete interfaces that do not relate directly to the spectator because when the public and the interface have a relationship of dependence this can create predictable results (Boden, 2005).

An example of an interactive artwork whose participants have a direct and notorious relationship with the interface is the work "Can You See Me Now?" (Figure 1.) by Blast Theory (2001). This work is a game in which participants search for each other using augmented reality information received on their mobile phones. The purpose of the game is to break the boundaries between the virtual world and the physical world, questioning the notion of absence and presence and provoking existential reflection in the participants. In contrast, an example of artwork with discrete interaction is "An Anecdotic Archive from Cold War" (Figure 2.) by George Legrady (1993). Based on a virtual archive of materials related to the communist regime in Hungary and other Soviet bloc countries, the interactive aspect of this work is discreet. Participants do not alter the work itself but rather select the narrative through which the information is presented, based on their personality and beliefs. The interaction the participant has with the work is reduced and consists merely of the tracing of the narrative according to the participant's social concerns (Kluszczynski, 2010).

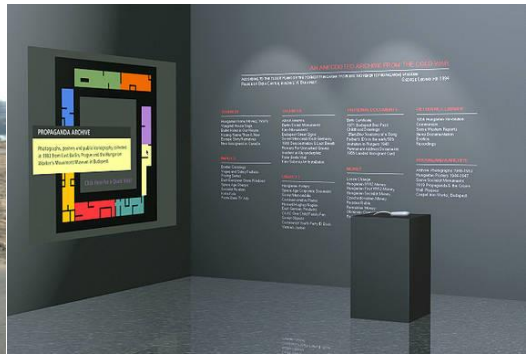


Figure 1. “Can You See Me Now?” by Blast Theory (2001). Figure 2. "An Anecdotic Archive from Cold War" by George Legrady (1993).

When it comes to new technologies, numerous questions remain unanswered and further experiments need to be made, as the aesthetic value of interactive means can be variable, unrepeatable, and completely different from existing art forms. In this work, we seek to characterize interactivity as a progression of states that evolve through decisions that a person applies to the machine's algorithm. When these transformations occur, the audience can engage in the work and appreciate the ability to interact, whether or not they are aware that they are taking part in a performance (Lopes, 2001).

This idea aligns with Lopes' argument in his work "A Philosophy of Computer Art" (2010), in which he defines the necessary aspects to classify a work as digital art: it must be considered art, created by a computer or designed for display on one, and utilize a common digital code. While Lopes' theory suggests that the display of interactive art is similar to traditional art display, Preston (2014) goes beyond this theory, explaining that interactive artworks are capable of having aesthetic and structural values as in traditional art, but can also have digital features as progressive structures, narrative, visual, audio and more. However, according to Wands (2007), digital art is extremely difficult to define, as digital tools are used in various artforms such as photography, animation, film, virtual reality, and net art, among others, and can result in a work that is either digital or analog. Consequently, to define a work as digital art, we have to determine whether this work is a result of a process in which the artist uses the computer as a primary tool, medium, and/or creative partner in the artistic process. Finally, after this evaluation, we must determine if the work involves the use of technology and the ideologies of contemporary art, the way it is created, and the intention of the digital artist.

After modernism, the emergence of abstract and Dada art led to the questioning of the spectator's position. These *avantgarde* movements were responsible for transforming the classic concept of art by working with experimental materials and practices, thereby enabling a transdisciplinary understanding of art. As a result of these movements, new aesthetic theories emerged, and the spectator's role was redefined beyond the limits of the work of art (Pinto, 2011). With the advent of interactive art, not only the artist but the audience became creators of unfinished and incorporeal artworks. Following the theory of Daniels (2008) regarding interactivity, there is no conclusive answer to whether it can be considered an ideology (in breaking down the barrier between creator/consumer and individual/collective) or a technology (interdisciplinary of various media), as it cuts across several fields. Nevertheless, the author clarifies that interactivity becomes accessible through the use of computers, enabling communication interpreted by a machine, which, through participation, creates an evolutionary technology under the needs of society.

To comprehend the distinctiveness of interactive art, it is essential to understand its semiotic differentiation from performance art. So, for this work, we will define semiotics as a study "concerned with everything that can be taken as a sign" (Eco, 1976: 7) and performance art as the activity that takes place between the work and the volatile event of a corporeal performance (Giesen, 2006). Although the audience's relationship with the semiotics of the artwork is similar in performance art and interactive art, in performance the body is analysed as a consequence of semiotics, whereas in interactive art the body is a place of exchange that influences events. This creates a problem for the uniqueness of interactive art is a dialogue between the participant and the machine, which, despite making the work a unique and unrepeatable event, blurs the aesthetics and meaning of the work. Nonetheless, this art form enables greater audience presence and immersion compared to non-interactive artworks due to the possibility of participation, aligning with Simanowski's (2011) notion of the contemporary cult of interactivity and the adapted motto *Creamus, ergo sumus*, which the author translates as "I experience, therefore I am". In our study, we are interested in highlighting perspectives such as that of Simanowski, who argues that experience and the will to participate are elements that have gained relevance in contemporary culture.

2.2 Biofeedback and Data Art

2.2.1 Data Art and Translation of Information

By “data” we understand a set of objects and their features, represented in a modular form with distinct elements. The field of data science that we have nowadays derives from the classic techniques of the 19th and early 20th centuries, whose ideas were enhanced through the use of computers from the second part of the 20th century onwards. The use of digital computers has become essential due to the methodological requirement of analyzing multiple variables simultaneously, not only because of agility, but also because digital computers can analyze a larger number of features practically. Nowadays, the phenomenon of representation allows the analysis of thousands of features that, in turn, allow the characterization of more complex objects (Manovich, 2015). Because of this, information can come from several insights with complex and heterogeneous cognition models and influence our apprehension of objects.

In this dissertation, we will focus on the practical application of data known as awareness insight, which involves maintaining a pattern of information based on data to provide users with awareness rather than arriving at specific conclusions. Data insights hold subtle data, conscious or unconscious, that can be applied to everyday situations. While the awareness insight is not properly applied to the usual analytical analysis of data science, this insight gives visualizations of the environment that may be relevant to an individual, a community, or the understanding of something personally relevant (Pousman, et al.: 2007). As information can be presented in different ways, we will investigate the awareness insights in physical graphical models. This choice is motivated by the under-researched nature of this form and the multitude of artistic interpretations it offers. Additionally, we want to highlight the reception of medical information through tactile senses to understand if this materialization enhances accessibility and understanding.

Stafford (1993) previously discussed the significance of medical images as a novel way of witnessing life, going beyond its aesthetic aspect of information visualization to become essential daily: "In today’s workplace, computer monitors “disembody” information into ghostly green or amber apparitions that float before our eyes” (Stafford, 1993: p. xviii). We agree with this statement and believe that medical information being visualized in innovative ways that are easy to understand and accessible is essential. That

is our motivation with this study with the hypothesis of applying this information to cinematographic creation.

For this study, it is important to understand the representation of data graphically instead of textually, which is called information visualization, a visual form of designing interfaces that connects perception and human cognition to create recognizable patterns. This representation can also be created through 3D layouts that can be reproduced graphically, which is called visualization of physical data. This way of presenting information is commonly used by designers who seek to innovate traditional data, exploring its visual design, aesthetic quality, and paradigms of interaction and navigation. Here, visual metaphors are meant to help users conceptually perceive a system through associations, and spatial metaphors attempt to use human uniqueness to recognize and organize objects in space to facilitate the apprehension of information (Andrew, 2005). One example of a data visualization 3D layout is the digital work "METACITY / DATATOWN" (1999), by MVRDV.

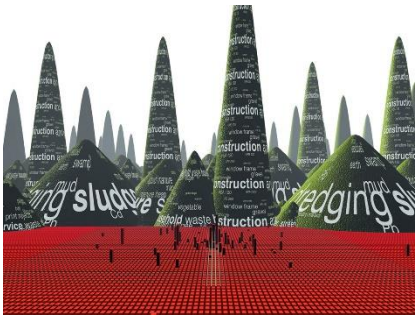


Figure 3. "METACITY / DATATOWN" (1999), by MVRDV (1999).

The objects resulting from the intersection of the spatial data domain and product design are classified by the term "Data Object", which can be domestic, educational, textile, or interactive objects that are usually created for product design, education, and research purposes. According to Sosa, et al. (2018), the principles underlying these objects involve treating data as a new type of design material, designing with accessibility and the possibility of reinterpretation in mind, and fostering cognitive and emotional engagement and empowerment. In this research, we will focus on analyzing the type of technology that promotes awareness through the collection, projection, and reinterpretation of information from the body, namely biofeedback.

2.2.2 Brief Concept: Biofeedback

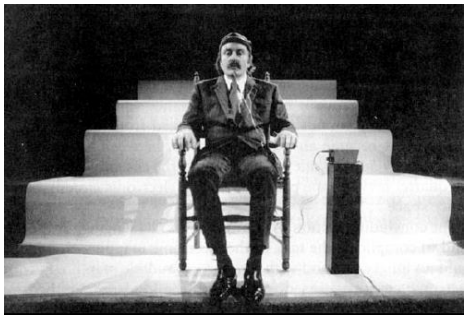
The term “biofeedback” was coined in 1969, to describe the laboratory processes created from the 1940s onwards, to teach patients to improve their medical condition through discrete information from their own body. This technology, commonly implemented in medicine, uses wearable sensors to collect data from biological signals to receive information on how the body responds to stimuli and observe its actions (Cao, et al. 2010). Thus, biofeedback can be defined as a process that reads physiological signals and translates them to an observer, encompassing all instruments that provide instant information and apply it (Gartha, 1976).

Despite its signs being accurate and precise, the biofeedback model is not only an instrument; it also needs to return the collected data to the user, taking into account psychophysiology, which is the study that relates physiology and human cognition. This means that for biofeedback to be effective and to teach the user to take advantage of their biological information, it must work by principles of environmental reinforcements, planning, cognition, imaging, and visualization (Schwartz, et al., 2016).

In the early days of biofeedback, researchers were unaware of the work that their colleagues were doing due to the lack of gatherings and journals dedicated to this area. However, nowadays, the research is extensive and covers multiple academic areas to achieve its most heterogeneous and profitable form (Peper & Shaffer, 2018). For this reason, biofeedback-based computing systems are increasingly being used in everyday life, and this real-time process of mapping physiological states allows, through interaction between a user and a computer, to present and modulate the result for its emotional, cognitive, and motivational interpretation (Moge, et al., 2022).

Although the interactive art of biosignal monitoring gained prominence in the artistic community in the 1960s through collaborations between artists, neuroscientists, physicists, and electrical engineers, its artistic research is limited compared to other technologies, despite the potential it offers in exploring the human body as a medium (this concept will be further explored later in the study). The idea of translating a biosignal into an art form had its first meaningful contribution in the essay "Primal Sound" (1919) by German poet Rainer Maria Rilke. The concept that originated in his text was put into practice in the 1960s, highlighting the work of the musicians Alvin Lucier and Richard Teitelbaum, who repurposed medical instruments to generate art through subtle changes

in physiology. For example, in the work “Music For Solo Performer” (1965), Lucier uses wearable devices to create a soundscape using brain waves (Gingrich, et al. 2014), and in the work “In Tune” (1967), Teitelbaum creates a performance using heartbeats, breathing and alpha brain waves (Teitelbaum, 2006).



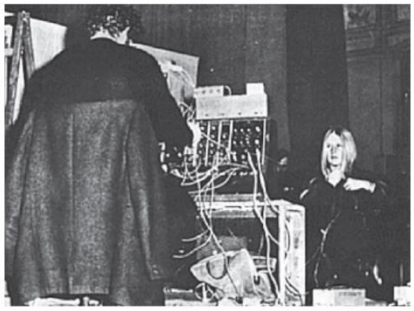


Figure 4. Alvin Lucier – “Music For Solo Performer” (1965). Figure 5. Richard Teitelbaum “In Tune” (1967).

In the 1980s, the accessibility of personal computers capable of processing digital signals in real-time opened up new possibilities for artists to explore and develop techniques for the application of biofeedback in various art forms. As we entered the 21st century, computers and medical equipment became accessible to an even greater number of consumers, and biosignal technology became more transparent, eco-friendly, and efficient.

Since biofeedback art uses tools that stem from the medical field, many questions regarding the emotional assessment and the interaction of physiological performance have accompanied this art form since its inception. One of the most recurrent challenges is how to make the dialogue between the observer and the artwork meaningful for the participants, as the lack of control over the biosignals themselves complicates the apprehension of aesthetics and requires greater care on the part of the artist to ensure a satisfying reception (Ortiz-Perez, et al., 2011).

This technology made possible a new way of experiencing the body and art as a dialogue, and by its means, it can analyse both natural and social phenomena. As this technology is focused on applications beyond the art gallery, participants have a fully interactive participation, perceiving the body not only as data but also as a living and sensitive subject. Biofeedback art is centered around the body and self-observation, and

its aesthetic foundation is rooted in enjoyment, fostering creative development (Neumark & Khut, 2007).

Biofeedback offers users a highly accessible means of presenting biological data, primarily through visual approaches. In this way, the user can understand the information through a display that allows them to interpret information for their benefit. One of the simplest forms of biofeedback is a mirror, as the mirror allows us to visualize our body's unconscious behaviors, such as joints and movements. However, this display does not allow us to understand what is happening beyond the surface and deeper understanding can be challenging (Cleland & Preston, 2020).

When it comes to biomedical measurement variables for users, there are two main types: direct feedback, which consists of sampling biosignals through numerical values, and transformed feedback, which consists of adapting this data into auditory, visual, and tactile displays, or even virtual reality environments. These measures can stem from the physiological and biomechanical qualities of the body, as the physiological measures encompass data from the neuromuscular, respiratory, and cardiovascular systems, while biomechanical measures include movements, posture, and strength.

According to Giggins, et al (2013), for neuromuscular biofeedback, technologies such as real-time ultrasound imaging (RTUS) and electromyography (EMG) are employed. Cardiovascular biofeedback utilizes technologies such as heart rate (HR), heart rate variability (HRV), and respiratory sinus arrhythmia (RSA) biofeedback. Respiratory biofeedback involves the use of electrodes or sensors attached to the abdomen. Biomechanical biofeedback relies on devices such as inertial sensors, force plates, electrogoniometry, pressure biofeedback units, and camera-based systems to measure movement, posture, and body strength. Lastly, pressure biofeedback employs a pressure biofeedback unit (PBU), which uses an inflatable cushion to measure pressure and muscle activity.

Beyond biofeedback, there is a specific area dedicated to helping users to gain control over the electro-physiological processes of the cerebral cortex, which scientists Yucha and Montgomery (2008) describe as “Neurofeedback”. This field uses electroencephalogram (EEG) and sometimes multi-site quantitative EEG (QEEG) to identify abnormal patterns and is applicable in physiological, psychological, and psychiatric treatment.

2.2.3 Biofeedback as a Data Translation Interface for Data Art

In linguistics, the term “feedback” refers to an evolutionary system that involves replicating and selecting mechanisms to obtain a correspondence. In this system, feedback serves as a dynamic and systematic foundation for coordinating and converging information in conversations between people, enabling effective communication (Zangwill, 2021). Similarly, in biofeedback, this mechanism occurs between a human and a computer.

As an artform, biofeedback is considered an interactive art that responds to the concept of endoaesthetics. Endoaesthetics is an aesthetics subtopic that complies with the ideas of endophysics, or the “physics from within”, defending that art has sensorimotor effects on the body. This aesthetic model, as stated in “Endo-Aesthetics”, by Gianetti (2004), refers to the transition of art to a complex system with several levels of interaction. Such artworks are often based on interactivity and aim to conceptualize the immaterial, integrate the viewer into the system and, that way, become an interface. These systems do not exist autonomously, as they rely on the observer’s actions to reflect their world, aiming to expand the participant's reality.

This study of the portrayal of reality through interfaces is what made the principles of endophysics expand into aesthetic theory. Endophysics is dedicated to studying what happens to a system when an observer becomes part of it. This idea is especially important for understanding the contemporary world where electronics are accessible and prevalent, as it argues that our interaction is not with the world, but with the world’s interface (Weibel, 1992). Reality, according to endophysics, emerges from the interaction between the observer, the state, and the relative, replicating the ideology of an interface. Thus, endophysics posits that reality exists only within the interface, and any changes to the interface will consequently affect our notion of reality (Tsuda & Ikegami, 2002).

As an aesthetic language, the notions of endophysics within endoaesthetics find expression in the digital realm, because, just as in science we can see small worlds of microorganisms through the microscope, Art challenges our perception of reality when the observer engages in a transparent conversation with an interface that integrates them into the system (Adams, 2010). According to Pais & Frias (2012), endoaesthetics can be the way to go against the automation of the world inured to the digital, for the reason that

this current constantly challenges the perception of reality. In Art, this is reflected in the way the artist must contradict the normalized and standardized way in which spectators perceive the world, offering them an opportunity to see through the artwork.

This quality of the body responding to experience causes embodiment in the transposition between body/mind and material/immaterial, drawing upon the significance of artistic production. Within interaction, we can have different types of interfaces, but it is the tangible interfaces such as biofeedback that allow an interaction called “passive interaction”, which refers to the body’s ability to unconsciously produce meaning through user engagement. The greatest faculty of this type of art is that natural actions that normally go unnoticed become the main action for the interface, increasing self-awareness (Zics, 2011).

An example of a work of art that uses discrete actions to absorb a new reality and even increase self-awareness is the work “Osmose” (1995), by Char Davies. In this virtual reality piece, the participant's breathing becomes the primary means of control within the virtual world. The act of breathing allows the participant to ascend or descend in space, acting as the center of balance for their three-dimensional experience. Inspired by the sensation of scuba diving, the exploration of "Osmose" through the entire body enables a kinetic experience that immerses both the body and mind (Davies, 1998).

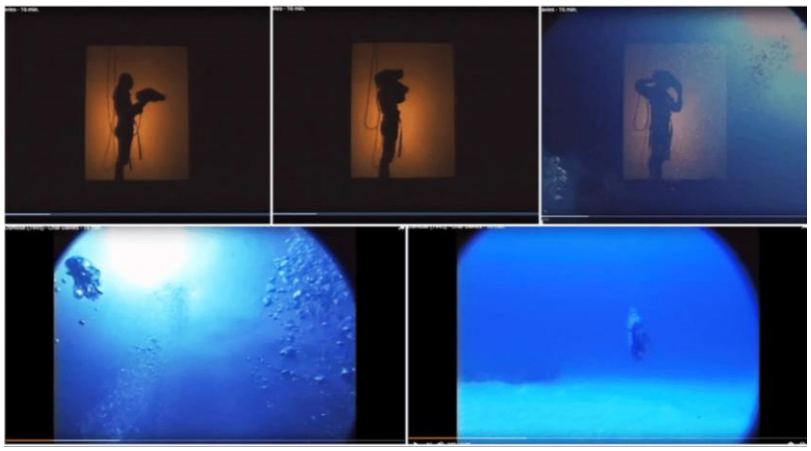


Figure 6. “Osmose” (1995), by Char Davies.

Nowadays, biofeedback can be represented by different sensory stimuli to enhance user feedback and attention. Affective computing, a field concerned with creating interfaces directed towards the user's affective state and behaviors, plays a role

in this development (Chittaro & Sioni, 2014). This field uses facial, speech, gesture and psychophysiological recognition to track emotional reactions and stimuli in response to audio, 2D and 3D videos (Li, et al., 2015). The hybridization of biofeedback and affective computing is known as affective feedback, and consists of the ability of a computer to return information in real-time that can affect the emotion and physiological state of the user, focusing this type of feedback both on direct influence of the user's bio-state and also in the way the information is presented. When applied, the computer's data serves two functions: the first is to perform the code and allow the user to react according to what is happening in the simulation, and the second is that the code is altered by affective feedback from the computer to improve the user's psychophysiological state (Bersak, et al., 2001). This blending between artistic expression with the realms of science and technology characterizes contemporary Art, particularly from the 1960s onwards, as the boundaries between artistic genres become increasingly blurred (Fogliano, 2017).

The introduction of biosignals in various artistic practices has brought forth several implications, including methodological, aesthetic, and epistemic considerations. Scientific advancements that have impacted Art include the availability of DIY biosignals, ongoing research to enable real-time diagnosis, and the emergence of brain-computer interfaces and affective computing interfaces. From an aesthetic and epistemic perspective, the integration of biosignals in Art to be received by the spectators expands communication channels that go beyond the ordinary. The main concern of this type of art is the participation and reception, inviting the public to experience their own inner state and perceiving biological data as objects of experience (Robles-Angel, et al., 2017).

One form of environmental art that affects both a viewer's well-being and health is architecture. Traditionally, architecture has not been responsive and does not adapt to the bodies and minds of its inhabitants. However, there are now architectural prototypes that incorporate biofeedback to change this vision, creating psychosomatic architecture that operates as a living system and introduces new types of materials. These smart responsive environments are great customization options that require participants' actions for aesthetic expression (Byrne & Cupkova, 2019).

2.3 Creating Physical Art using Biofeedback Information

2.3.1 What is a Material? – Traditional and New Perspectives in Art and Biofeedback Interactions

Materials are cultural goods with immense possibilities of representation encompassing both traditional and innovative forms. When examining the characteristics of materials, we consider factors such as the selection of raw materials for the object's construction, the tools used, the energy source, the techniques employed in manipulation, and the sequence of operations. The visual and tactile characteristics of these materials are equally influenced by the context of their creation and their intention. It is the visual and tactile necessity of the material as a medium that determines the choice of its colour, texture, decoration, hardness and shape (Sillar & Tite, 2000). Due to the advances of graphic computing, there is a growing focus on analyzing specific material characteristics to enable more sophisticated and realistic simulations and visuals, which are crucial for rendering and animation algorithms (Müller & Gross, 2004).

In the realm of architecture, the widespread adoption of touch-based interaction with computers, particularly through touchscreens, has led to the implementation of interactive surfaces that extend beyond hand-based interaction to encompass the entire surface. One example of this is "Slow Furl" (Figure 7), a collaborative project by Mette Ramsgard Thomsen and Karin Beck (2008). This mobile architecture project uses simple mechanisms to manipulate walls composed of soft textiles as an outer layer. In this work, technology uses computer programming to make a closed loop of movement that triggers its own results. In this way, the reinforcement that is created through these movable walls, in addition to the tactile armour, allows a three-dimensional perception of the surface and provides a dynamic environment, different from traditional architecture (Thomsen & Hicks, 2008).

Figure 7. “Slow Furl”, by Mette Ramsgard Thomsen and Karin Beck (2008).

In architecture, touch has become a form of interest for artists beyond its traditional visual stimulus and design. This is because touch-based interaction and the development of interactive surfaces have become areas of interest, potentially shaping the future of architecture.

An example of a space that is careful to use touch not only as an aesthetic, but also as a narrative, is the Musée du Quai Branly – Jacques Chirac (Figure 8). In this museum, to enter the main exhibition room, it is necessary to go through a dark tunnel that leads to a room with tall brown leather walls. Due to the appearance of this material, when the public arrives at the exhibition plateau, they enter an unexpectedly dark world, like a cave. Through this experience, the atmosphere evokes a feeling of spirituality and primitivism. Since the museum features the indigenous art and cultures of Africa, Asia, Oceania, and the Americas, the architectural design contributes to conveying a critical message regarding France's colonial past and post-colonial present. In this way, something as simple as leather walls turns out to be a critique of the reluctance to decolonization (Demissie, 2009).

Figure 8. Oceanic exhibition hall at the Musée du Quai Branly – Jacques Chirac, Paris, France. Photo by: Andreas Praefcke / Public domain.

When interacting with a tactile surface, two simultaneous aspects come into play, the active and the reactive components, and the high sensitivity of the skin to textures, temperatures and densities allows the existence of three channels of sensation, the kinaesthetic, the tactile and the haptic. Kinaesthetic perception refers to our perception that something is moving, due to the reception of information by muscles, joints and

tendons; tactile perception refers to passive stimuli of the skin; and haptic perception refers to the reception of sensations produced when we actively explore an object. Touch is also often associated with other senses, with the visual being the most predominant. This is the concept that interactive architecture wants to demystify, employing haptic surfaces to engage the body and question how architecture can be felt rather than merely seen. To achieve this effect, it is crucial to understand haptic qualities as a spectrum of physiological understandings and explore new possibilities for interaction (Pohl & Loke, 2012).

Unfortunately, smart materials remain underexplored, especially within predominant work groups involved in the construction of environments with artistic potential, such as designers and architects. These materials offer opportunities for architecture to achieve innovative forms of interaction and kineticism, challenging the traditional notion of materialism and enabling the transformation of mechanical and static elements into organic ones. Smart materials prove particularly relevant in contexts such as storytelling, visualization of the intangible, fostering pleasurable and emotional experiences, and creating new spatial and meaningful dimensions. The adaptability of these materials opens up multi and interdisciplinary possibilities (Nabil, et al., 2017).

Furthermore, there are specific types of materials utilized in medicine known as biomechanical-responsive materials and biomechanical-stimulatory materials. Developed through biomedical engineering, these materials serve as interactive interfaces and, because they are programmable, they are significant to the scientific and technological developments of bioresponses. Leveraging information from physiology, biophysics, and biomechanics, these materials are primarily used to improve the user's health. Their adaptability allows for preventive measures and monitoring, significantly improving the quality of life for individuals with biological disabilities and providing awareness insights (Cai, et al., 2018).

2.3.2 Artistic Outputs

There are several possibilities for the visualization of information and its physical representation. Next, we will analyse some examples and the evolution of physical visualization through history and artistic representations of medical information.

Physical visualization of data has been present throughout history, with one of its earliest forms being tokens. Tokens were a system created around 7500 BC with the aim of helping workers, leaders and communities to count units of goods (Schmandt-Besserat, 2013). For this thesis, we are interested in studying complex systems of data, so we are going to contextualize the use of visualization at the beginning of the 20th century to understand how the rise of personal computers in the turn to the 21st century changed their aesthetic description.

One of the oldest exercises that we will address is a statistical study of forty university of Chicago students arranged by classes of stature (Davenport, 1901), corresponding to Figure 9. This model consisted of ordering students by height classes, resulting in a frequency of polygons without the need for drawn graphics. Another example is the 3D graphic of Figure 10, which represents tests conducted on a direct-connected fan and engine. This model, made of cardboard with simple intervals, presents information in a straightforward, easy-to-understand, and cost-effective manner. This model can be manipulated without the need of machinery, which at the time was a very laborious process (Brinton, 1919). Figure 11 illustrates 3D wire models of hand motion paths, representing the hand motion of a manager on a drill press, which he did not operate for 20 years. This visualization, created in wire, is also easy to manipulate and an effective way to present information, providing a valuable insight for optimizing employee work (Gilbreth & Gilbreth, 1919).

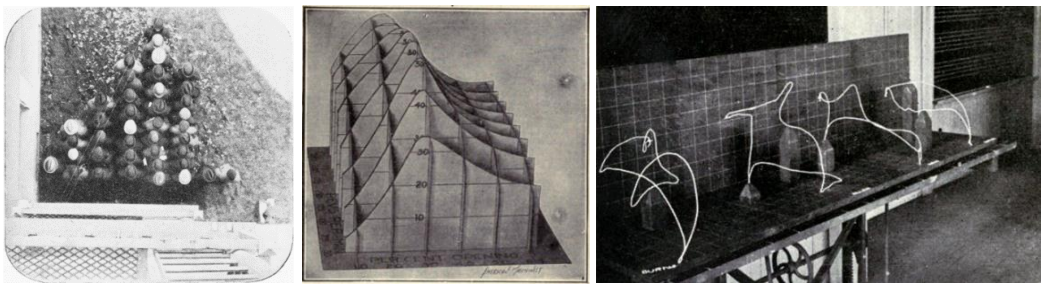


Figure 9. Bird's-eye View of 40 University of Chicago Students arranged by Classes of Stature (Davenport, 1901). Figure 10. Tests of a Direct-connected Fan and Engine (Brinton, 1919). Figure 11. 3D wire models of hand motion paths (Gilbreth & Gilbreth, 1919).

Years afterwards, the first example of a complex physical visualization that used a computer for its design was Dorothy Hodgkin-Crowfoot's photograph of electron-

density contours from the 1949 penicillin monograph, as shown in Figure 12. This visualization was made possible through the investment of the Medical Research Council and the methodology developed by Comrie's Scientific Computing Services Ltd. The work gathered a substantial investment because in the wartime in Britain penicillin had an enormous military importance (Cranswick, 2008). Hodgkin's physical visualization uses a black pen to draw the electron density contour of the penicillin molecule on horizontal sheets of acrylic, and, as they are separated and aligned, it creates a 3D effect.

Inspired by the captivating aesthetics of Hodgkin's representation, the artist Angela Palmer sought to bridge the gap between science and art, so the artist adapted the multilayer aspect of the Electron Density Contours for artistic purposes. The artwork we want to highlight is "Heart of Glass" (2018), in Figure 13, which uses a series on Magnetic Resonance Imagery (MRI) of a cannulated heart to recreate a drawing of a human heart (Craven, 2018).

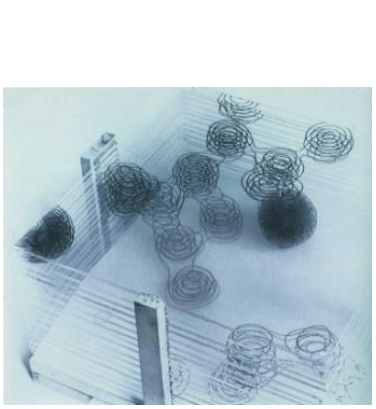


Figure 12. Electron Density Contours by Dorothy Hodgkin (1949). Figure 13. "Heart of Glass" by Angela Palmer (2018).

Just like Angela Palmer uses MRI images for her work, the artist Neil Fraser uses the same biofeedback technique to represent the complex neurological imaging system. In his work "Wooden Brain" (2008), Figure 14, the artist uses 266 wooden cubes that can be interacted by the public to obtain different results. By dividing and rearranging the cubes, users can match different layers of the MRI (Fraser, 2008).

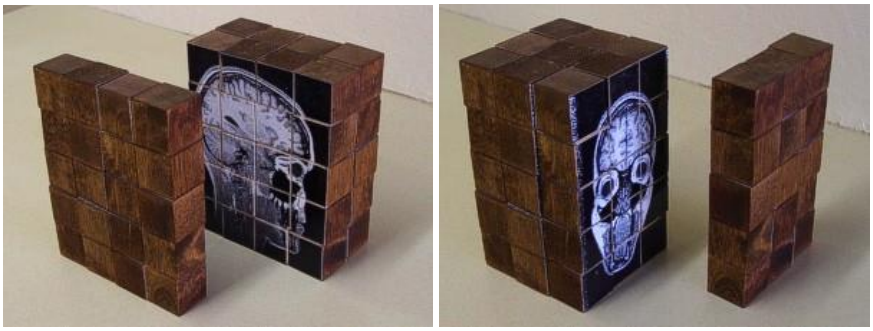


Figure 14. “Wooden Brain” by Neil Fraser (2008).

We also want to highlight two works that use computers and high-tech biosensors with the objective of visualizing awareness insights. The first example is the visualization of cardiac blood flow data, as seen in Figure 15. This model was created using information obtained by 4D cardiac flow MRI and printed on a 3D printer, allowing not only medical professionals, but also their patients to have a tangible object to complement their interpretation of anatomical heart information (Ang, et al., 2019).

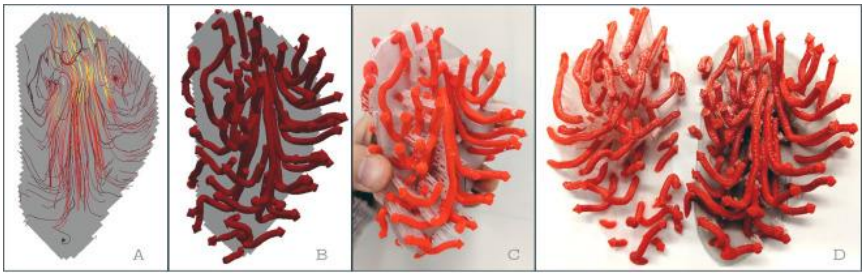


Figure 15. Process of fabrication of the Blood Flow visualization model (Ang, et al., 2019).

Finally, the visualization example with high-tech biosensors was used for the study “Dermal Tattoo Biosensors for Colorimetric Metabolite Detection” (Yetisen, et al., 2019), in Figure 16. In this study, dermal tattoos embedded with sensors were implemented in patients to detect pH, glucose, and albumin concentrations, providing real-time information to the user. This device, with the aesthetic of an ordinary tattoo, enabled patients to monitor body processes with the aim of improving their quality of life.

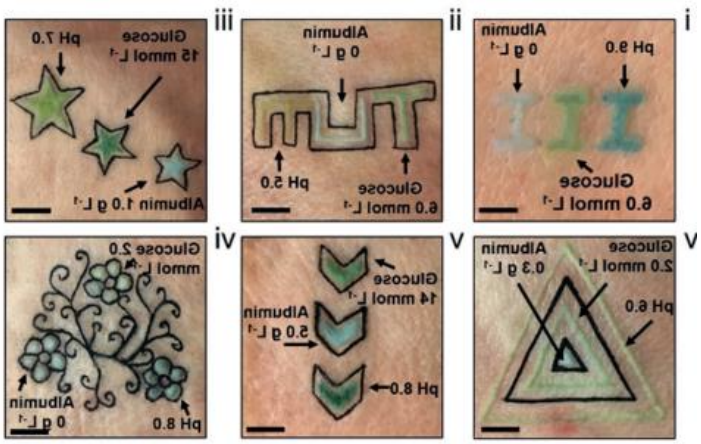


Figure 16. Tattoo Biosensors (Yetisen, et al., 2019).

Based on this chapter, we can conclude that biofeedback, despite primarily finding applications in the medical field, possesses significant artistic, conceptual, and aesthetic potential.

It is because of the way biosignals are interpreted by a machine or computer that we classify this technology as an interactive translation interface, not only because of the ability to participate, but also because it results in a continuum and permanently unfinished flood of information. This unique and irreplicable extension of biological visualization has allowed us to understand that clinical biofeedback relies on graphic representations designed to present easily understandable data through visual, auditory, and tactile features. The utilization of such features in presenting information aligns with research in the fields of architecture, design, and education.

In this study, our focus was on exploring the translation of data in physical and tactile materials. To accomplish this, we first needed to understand how the physical representation of data started and how its aesthetics and usage progressed from analogical to technological means. Through the analysis of multiple case studies, we discovered that, similar to biofeedback, the materialization of data became more accessible and increasingly explored by artists following the widespread adoption of personal computers. From this event on, works of art that explored the relationship between users and materials through the visualization of biological information from the body gained more prominence. In line with the prevailing ideals of the time, biofeedback-driven interaction emerged as a response to the contemporary desire for experiential sensations, echoing the motto *Creamus, ergo sumus*.

3 Expressions of Vision-Touch Synaesthesia in Literature, Art and Moving Image

To establish a connection between biofeedback and animation cinema in terms of their impact on viewers through aesthetics and narrative, it is important to delve into the study of synaesthesia, because both areas have a great propensity to provoke synaesthetic reactions in the spectator and, as there are no works that combine both fields, we believe that creating a relationship of similarity through synaesthesia helps us to understand the potential of combining biofeedback and animation.

Just as we have observed that elements such as kinaesthesia, touch, and haptics facilitate the apprehension of information through tactile contact, these elements are also inherent in synaesthesia and art in general. Thus, our next step is to explore synaesthesia in literature and art, identifying patterns that will support our thesis and reflect them in narrative and aesthetic theories of Art.

3.1 Synaesthesia: Brief History, Synaesthetes and Non-Synaesthetes

Essentially, synaesthesia is a complex form of perception that occurs when information is simultaneously perceived by different senses. This phenomenon operates on an additive principle, wherein an additional sensory modality is triggered alongside the primary modality stimulated by a given sensory input (Day, 2002).

In synaesthesia's pathological definition, the first and lesser-known medical report of this phenomenon was explored by Georg Sachs (1812), who carried out the study of his own condition as a synaesthete, and his experience with "coloured ideas", writing about the first documented case of synaesthesia (Jewanski, et al., 2009). Years later, in 1880, Francis Galton continued the report of synaesthesia as a condition. Galton became aware of this condition in certain people as these individuals experienced multiple modalities of sensation with single modality stimulus. In his research, he found that synaesthesia is a sensory phenomenon that comes from the cross-activation between the stimuli and the correspondence of neurons receiving the information (Ramachandran & Hubbard, 2003).

While both Sachs and Galton classified synaesthesia as a rare genetic condition that affects the brain and induces inter-sensoriality, the concept of synaesthesia has evolved to encompass not only individuals who suffer from the condition but also those who experience synaesthetic perceptions non-pathologically, referred to as non-synaesthetes. The main difference between these two groups is that, in synaesthetes, synaesthesia occurs pathologically, and in non-synaesthetes this perception is conceptual and metaphorical, not congenital (Howes, 2011). For this reason, we want to separate the two groups of individuals as synaesthetes, being individuals belonging to a reduced percentage of the population who experience sensations in an extraordinary way, and non-synaesthetes, as the majority of the population that have a common mechanism of conscious cross-modal associations (Simner, 2012).

Although the scientific perspective on synaesthesia is relatively recent, the concept of synaesthetic associations has roots in ancient Greek rhetoric, particularly in Aristotle's theory (1954 (c. 330 B.C.)), following the ideas of merging senses in metaphors, connotations and associations (Day, 1996). On one hand, due to the perceptual information induced by sensations or stimuli, synaesthesia can be perceived by non-synaesthetes, complementing the transposition from one modality into another by reasoning or similarity. On the other hand, synaesthetes attribute consistent meanings to stimuli, such as a particular letter or number by a specific colour. For example, when a synaesthete sees the number 3 in green, but it is written in another colour, such as yellow, the altered appearance interferes with their comprehension of the information. This association also differs from synaesthete to synaesthete, as one can consistently visualize the number 3 as green and another the number 3 as red (Marks, 2017).

It is possible to create a clear distinction between synaesthetes and non-synaesthetes, and allege that synaesthesia is achievable among all individuals, regardless of whether it is pathological or associative.

According to Rogowska (2011), the main types of synaesthesia are vision–sound, touch–taste, colour–smell, touch–hearing, and coloured–hearing synaesthesia (also called chromesthesia). Besides these, the most prevalent types are time-space, grapheme–colour and mirror–touch synaesthesia. Also, in the book “Wednesday is indigo blue: Discovering the brain of synesthesia.” by Cytowic and Eagleman (2011), about 40 types of synaesthesia and their frequency in more than 700 participants are listed.

3.2 Vision-Touch Synaesthesia in Literature and Art

If we understand creativity as the ability to create associations and adapt concepts, we can speculate that people more prone to synaesthetic perceptions are more likely to be creative, as synaesthesia is also the ability to link unrelated phenomena and ideas. As we have come to understand, synaesthesia is perceived by both synaesthetes and non-synaesthetes, even though, for synaesthetes, this connection is intuitive, and for non-synaesthetes it is created through cognition using metaphors. In the realm of Art, synaesthetic inspiration and experiences can be found in various forms such as poetry, music, and visual arts (Ward, 2008).

Metaphorical synaesthesia is usually represented in Literature and Art, as these areas use metaphors to convey deeper meanings. To provide a synaesthetic experience, Literature and Art work with associations and transfers between senses, which may be in concept (meaning or emotional) or form (structural) (Galeyev, 2002). Within Literature, this technique is known as literary synaesthesia and encompasses metaphors that interconnect multiple senses in the writer's work. To create this effect, the writer uses conscious associations and memories to create a chain of meaning, to introspectively express a stimulus or make the text more appealing (Ruddick, 1984).

In English Literature, some examples of words that refer to multiple senses are expressions are “sharp taste” (touch transferred to taste), “sour smell” (taste transferred to smell), “bright sound” (colours transferred to sounds), among others (Cacciari, 2008).

Literary synaesthesia has been the subject of study since the 17th century and plays a fundamental role in both Science and Art, as Art employs associations and symbolism to convey profound meanings. Without coincidence, numerous artists incorporate synaesthesia in their work, such as the painters Vassily Kandinsky and Carol Steen, who often associate colour and music (Ione & Tyler, 2003; Duthie & Duthie, 2015), Jack Ox, an intermedia artist who seeks to translate sound into visual images, and Marcia Smilack, a photographer who looks for reflections in puddles of water that resemble musical notes (Ione, 2006).

Figure 17. “Improvisation 26” by Vassily Kandinsky (1912). Figure 18. “Runs Off in Front”, by Carol Steen (2003). Figure 19. “Ursonate” by Jack Ox (2014). Figure 20. “Cello Music” by Marcia Smilack (2005).

For this study we want to focus on the creative applications of vision-touch synaesthesia, to further understand the expressions of this phenomenon. For that goal, we will first study how this type of synaesthesia evolved in different media, then analysing three subtypes within the vision–touch synaesthesia: touch–colour, mirror–touch and touch–screen synaesthesia.

Regarding touch–colour associations, there are two reported forms of experience in synaesthetes. The first is associated perception, and the second is projected perception. The associated perception is when an individual, while touching a surface, experiences the colours they associate with that surface in their mind, and the projected perception is when an individual experiences colours projected in a part of the body that is being touched. For non-synaesthetes, the most common form of touch–colour association is to have a relationship between the stiffness and texture of a surface and the lightness of the colour, for example, to associate softness with lightness and stiffness with strong colours, depending on the individual (Simner & Ludwig, 2012).

One artistic example of touch–colour synaesthesia is the work “Vision” (1996) by Carol Steen, in which she painted a visual representation of the needle pressure during an acupuncture session (Safran & Sanda, 2015).

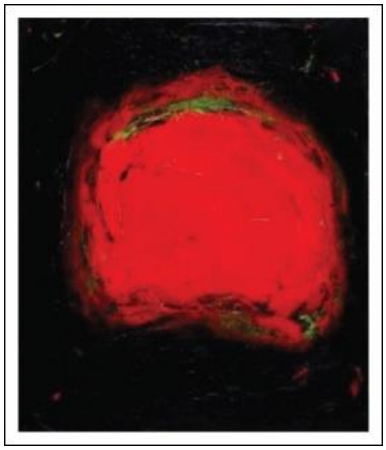


Figure 21. “Vision” by Carol Steen (1996).

Mirror–touch synaesthesia is a form of perception in which a synaesthete has neurological overactivity when observing people being touched. In this perception, touch is stimulated through vision, and the body of the synaesthete feels the same touch that is being applied on the observed body part, as if it were a mirror. According to studies, non-synaesthetes are less sensitive to the effects of mirror-touch when observing people being touched than in people touching objects, which does not happen in synaesthetes, who are more sensitive to touch that a person receives for another, mirroring that sensation in their own bodies (Blakemore, et al., 2005).

One artistic example of mirror–touch synaesthesia is Daria Martin's “At The Threshold” (2015). This short film portrays the synaesthetic experience between a son and a mother who share the sensation of touch and pain between their bodies. These sensations had already been explored in the first film of the director's trilogy “Sensorium Tests” (2012), but in this film the search for scientific answers behind mirror-touch synaesthesia is also transited by the experience that a spectator has in the movie theatre (Reynolds, 2016).

Figure 22. “At the Threshold” by Daria Martin (2015).

Touch-screen synaesthesia refers to the phenomenon where a person's touch on a touch-screen device prompts a visual response. This occurs when touch creates a synesthetic sensation on the sensor due to the correspondence between touch and movement, speed, acceleration and angle visible on the screen. This way, gestures are apprehended as information for position, contact and movement and synchronized with the screen device (Hinckley & Song, 2011).

An artistic example of this form of synaesthesia is the work “Six-Forty by Four-Eighty”, by Zigelbaum + Coelho (2010). This interactive installation uses 220 tiles of light, and works with the concept of a pixel in order to understand what our interaction with a computer would be if, in the future, computer interfaces could be physical and not restrained to screens and keyboards. In this work, the interaction serves as an information conduit for change grid properties. When a participant touches a pixel-tile, their form of touch, movement and position changes the properties of that pixel, allowing them to repeat and replace the properties of each tile (Zigelbaum & Coelho, 2011).

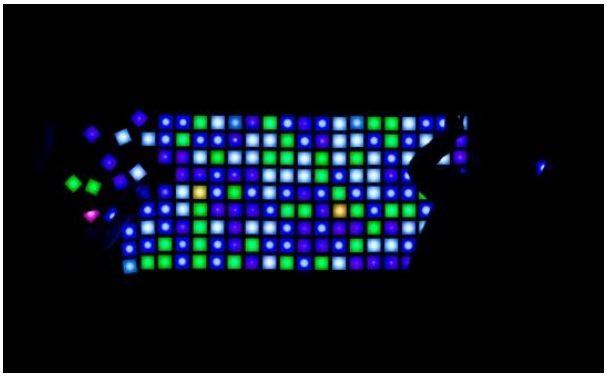


Figure 23. “Six-Forty by Four-Eighty”, by Zigelbaum + Coelho (2010).

Another type of vision-touch synaesthesia is the haptic, a property of touch that is not immediate, so its form of experiencing serves to understand objects through touch in a way beyond vision. Since touch is a sense usually reduced by sight, the capacity to perceive an object haptically allows for a more plastic, tactile and intimate understanding (Paterson 2011). In this way, the haptic is a form of exploration that involves movements and sensations of the skin to receive information on plasticity, temperature, and vibration, among other features of the objects (Fulkerson, 2011).

In the subsequent part of our study, we will study the haptic and its representation in moving image to understand how this perception, which we classify as “beyond sight”, has a presence in the audio-visual medium.

3.3 Haptics in Moving Image

According to Marks (1998), haptic visuality is a term that derives from optical visuality. However, in haptic visuality, the body is involved in the observation process, which makes the viewer more present in the film experience, creating a relationship between the camera and the moving body, and between the eyes and the image. For Marks, the cinematographic image is imbued with tactile impressions, and haptic visual characteristic carries an erotic appeal that makes the eyes function as tactile organs.

In a film, the cameraman captures reality in a manner distinct from that of a painting, as painters often strive to create a deliberate separation from the real world, while the cameraman's objective is often to display reality within the limits of the cinema screen. This results in a physical shock while watching cinema, that forces the audience to adapt to the construction of scale, time, and space within the images (Lant, 1995). Since touch is an essential aspect of how our bodies understand the world, the incorporation of this sense in cinema not only promotes embodiment but also establishes an immediate and reciprocal connection between the film and the spectator (Paszkiewicz, 2020).

Just as we classify the optical image as a practice of seeing representations, the haptic image uses tactile, kinaesthetic elements and provokes sensations as an organ of touch. Therefore, the haptic is the relationship that the subject has with the environment one integrates into, suggesting that the audience perceives a film not only in an audio-visual manner but also in a tactile manner.

When the spectator perceives information through the skin, we call this haptic perception, which is when we perceive the world without the use of optics, but solely through the skin. This understanding is crucial in defining haptic perception since it might be mistakenly assumed that the haptic is a form of vision reflected in touch. In reality, the haptic represents a way of "seeing" through the skin. It is a conscious perception that places the body at the centre of understanding the world of touching and being touched. When we watch a film, our body reacts with heat, tension, pleasure, or pain as a form of contact between the spectator and the screen interface (Laine, 2006).

Bruno (2010) argues in her work that the artform most analogous to Cinema is Architecture, as both work for a spatial-visual result, and Cinema uses this capacity to also create a tangibility between time and space, consequently establishing a sense of physical presence and “electrified” movement. For the author, the electrical construction in Cinema is also significant. Light is described as an energetic force that draws the spectator to the screen when seated in a dark movie theater, challenging the boundaries between space and touch, as space itself also touches the spectator and extends beyond their physical body.

3.3.1 Apparatus Case Studies

While the haptic can be observed in recent technological advancements, it can be traced back to earlier devices such as the Stereoscope, which gained prominence in 1851. In the Stereoscope, the combination of the optic and the haptic to create three-dimensional analog images was explored, even though in the time of its technological vogu, three-dimensionality was still underdeveloped and the engine was often described as “uncomfortable” (Trotter, 2004).

In terms of modern technologies, the quest to incorporate touch in cinema led to advancements such as the Sensorama, a system that allowed not only to watch 3D films but also feeling wind, vibrations and odours (Guillotel, et al., 2016). This product was inspired by the concept of virtual reality described by Stanley G. Weinbaum prior to the 1950s, in the science fiction book “Pygmalion’s Spectacles”, which portrayed a holographic system with touch and smell features. Created in 1962, Sensorama was developed by Morton Heilig. This device involved a person sitting in a chair and placing their head inside the machine and, from there, visualize the films in an integrated ocular

system, also being able to experience sounds, smells and touch. For its multisensorial particularity, Sensorama can be seen as the first 4D cinematographic system (Della Croche, et al., 2016).

In the film industry, terms like 4D and 5D are used to describe cinemas that utilize advanced sensory technologies. While traditional Cinema is 2D, 3D Cinema is cinema with characteristically tactile image quality due to its technique and immersiveness, 4D Cinema is when the viewer has diegetic sensations, and 5D Cinema is when the viewer moves in space. In addition to these technologies, touchscreens, as we described earlier as examples of touch-screen synaesthesia, are part of dynamic and performative interfaces (Jackman, 2015).

Furthermore, haptic techniques are employed in contemporary virtual reality systems to provide immersion, embodiment and emotion associated with the digital environment (Danieau, et al., 2014).

3.3.2 Filmic Case Studies

The haptic has always been present in the history of Cinema, and the tactile quality of images can be observed in early films, including the works of the pioneer brothers Lumière and Méliès. This effect is achieved through the filmmakers' care about the spatial composition of the images, transmitting to the spectator a perception of three-dimensionality without the spectator having to move. In the example of Méliès' films, the sets present in the director's films consist of coloured panels, and the movement of the actors was what affected the screen, creating a spatial illusion that made the spectator believe they could reach out and touch the images (Ghahramani, et al., 2014).

Figure 24. “The One Man Band”, by Georges Méliès (1900).

The reciprocal relationship between the screen and the viewer, vision and touch, the eye and the skin, are part of the essence of Cinema and has been explored since the beginning of this artform. In the short films “The Cabinet of Dr. Caligari” (1920), by Robert Wiene, and “Le Chien Andalou” (1929), by Luis Buñuel and Salvador Dalí, this relationship is notorious, with both films using contrasting shots of eyes and hands to enhance materiality and provoke a tactile response. Similarly, in the feature film “Orphée” (1950), by Jean Cocteau, the protagonist’s hands, when in contact with a mirror, open the door to another dimension, exemplifying the recurring use of this phenomenological metaphor (Stephens, 2012).

Figure 25. “The Cabinet of Dr. Caligari”, by Robert Wiene (1920). Figure 26. “Le chien andalou”, by Luis Buñuel and Salvador Dalí (1929). Figure 27. “Orphée”, by Jean Cocteau (1950).

In the previous films, the sensation of tactility arises from the body and its intimacy with the screen. This is also evident in David Fincher’s “Fight Club” (1999), a feature film that uses textures, surfaces and materials for the viewer to experience a more significant embodiment. Regardless, given the film’s theme of alienation and detachment, the haptic is often used in an extreme and unconventional way. In the film, the characters Tayler and Jack represent opposites. Tayler is an alter ego of Jack, who has characteristics that Jack does not have, and causes Jack to distance himself from his own reality. Throughout the film, touch intensifies Jack’s experience of the world in an affective and existential practice. In addition to the film using techniques such as camera movements and textures, the manner the bodies move and interact creates a strong sense of embodiment. In the fight scenes (Figure 28), for example, the spectator does not have pleasant sensations, as the images express disgust, pain and stickiness, which manifest in the spectators’ skin. Still, when the characters Jack and Marla meet, the touch is

sexualized, gentle and affectionate, which can be a sign of their encounters and romance as a way of affirming Jack's existence and feelings (Littschwager, 2016).

Figure 28. "Fight Club", by David Fincher (1999).

In Mar Coll's first short film, "La última polaroid" (2004), the haptic effect that comes from the grainy image is not only a stylistic element, but provokes nostalgia. In this film, the haptics complement the narrative and mark a position against the contemporary visual culture addicted to high-definition imagery. The story follows two friends, Mariana and Eli, on the last night they spend together before Mariana moves to another city. The emotional state of these two teenagers is portrayed in the storyline through catalysis and ellipsis, and visually through close-ups, hand-held camera movements, out-of-focus shots and photographs little revealed by the Polaroid camera that symbolizes the transitional moment the characters are going through. This film uses elements that evoke tactility to allow the viewer to imagine what is narratively ambiguous, letting the audience imagine the gaps of Mariana and Eli's story, turning them in an active spectator (Guillamón-Carrasco, 2020).

Figure 29. "La ultima polaroid", by Mar Coll (2004).

Finally, in the animated feature film “Belladonna of Sadness” (1973), by Eiichi Yamamoto, we can witness how the haptic works differently in animation than in live-action cinema. Because, despite equally including camera movements, textures and touch, the graphics achieved through painting, lines and chromatic pigments provide a rich aesthetic and synaesthetic experience. The haptic quality is highlighted in the visual design, as this film uses high contrasts and colour saturation to construct a visually noisy world that also shows the inner world of the main character, Jenny. When Jenny is presented by her innocence, her eyes have delicate and clean textures; when she cries, tears run down her face so the audience can sympathize and feel her sadness; and when she is raped (Figure 30), the screen is filled with a black and red cloth that encompasses Jenny, tearing her apart repeatedly until the cloth transforms into red bats. In the rape scene, the texture of cloth is used so that the audience has an immediate tactile feel of what is happening to Jenny, and the haptic plays a crucial role in conveying a deeper understanding of the character's emotions (YiTong, 2021).

Figure 30. "Belladonna of Sadness”, by Eiichi Yamamoto (1973).

In this chapter, we have provided a brief overview of the presence of vision–touch synaesthesia in Literature, Art and Cinema. In order to fulfil this objective, it was necessary to classify this form of synaesthesia in non-synaesthetes, to understand prevalent forms of association and in synesthetes to establish subtypes such as touch-color, mirror-touch, and touchscreen. Then, it was necessary to find artistic examples for each.

For this study, the elements that we found essential to provoke synaesthesia by vision-touch are, in Literature, the use of associations and memories, in Art, sensorial modality translations and symbology, and, in moving image, embodiment and haptics.

We have particularly highlighted the evolution of haptic apparatus that intended to provide greater three-dimensionality and immersion to cinema, while defining the screen as an interface.

With this chapter we can conclude that, although this form of synaesthesia is less explored academically, its manifestations in every artdorm are current and prove to be relevant to spectatorship.

4 Metaphors and Visual Representation in Animation Cinema

After studying different forms of vision-touch synaesthesia in Art, including Cinema, this chapter focuses on the presentation of metaphors in animation cinema. As we have seen, metaphors are a significant aspect of synesthetic association. So, to study these perceptive manifestations in animation cinema, especially trough the stop-motion technique, which we will explore in the upcoming chapter. By gaining a deeper understanding of the fundamental characteristics that contribute to the immense potential of animation as an art form, we can better value its capacity for synesthetic expressions.

Before studying Animation's ability to harbor metaphors and representations in its works, accompanying the investigation with case studies, we will make a brief mention of how we classify Cinema as a language and define Animation as a cinematography that employs different techniques.

Starting by quoting Bazin in his book "What is cinema?" (1971, p.16) "on the other hand, of course, cinema is also a language", we can follow Metz's theory (2011) when is stated that what we commonly understand as Cinema is a multidimensional phenomenon that needs a diversified study of its multiple elements, as we will do here concerning its language. Cinema had its first exhibition in 1895 through the lens of the Lumière brothers and since its inception, it has displayed the ability to harbor psychological, psychoanalytical, social, political, and ideological meanings in its content (Metz, 2011). This ability of cinema to reinvent itself as an art is due to its adaptability to artistic concepts prior to its creation, which is why it is a medium of countless possibilities, as the acclaimed director Jean-Luc Godard says:

> "[…] the cinema is not an art which films life: the cinema is something between art and life. Unlike painting and literature, the cinema both gives to life and takes from it, and I try to render this concept in my films. Literature and painting both exist as art from the very start; the cinema doesn't." Quote from Jean-Luc Godard in (Roud, 2019: pp 6).

Animation Cinema captures the essence of live-action cinema by reconstructing its principles through frame-by-frame reconstruction. In this perspective, Cinema and Animation are neither subject to each other nor are they separate. They rely on the mechanisms they share to redefine cinematography technology and aesthetics.

Regardless of technique, aesthetics, lines, or vectors, animation aims to create movement (Johnston, 2021).

Despite the historical division between live-action and Animation, these formats converge in digital Cinema. In the 20th century, Animation was usually considered inferior to live-action Cinema and assumed to be a depository of techniques that live-action abandoned after the 19th century. However, in the digital age, Animation brought fundamental tools and became commonplace in Cinema, so much so that now it is almost impossible to distinguish a graphic element from a photographic one (Manovich, 2008).

4.1 Metaphors and Visual Representation

As we have emphasised, Animation has the ability to create worlds, breaking the barrier between the real and the fictional. It is because of the openness to creativity and experimentation that Animation unleashes extraordinary possible within the screen. While live-action cinematography is expressed through frames, shots, scenes, sequences of images, and composition of characters and actions, Animation has these elements, and also allows their manipulation in terms of image, size, light, colour, movement and continuity. In this way, the worlds presented in animated films have extended meanings and adjust the representations according to the work.

In Disney's iconic films such as "Lion King" (1994), by Roger Allers and Rob Minkoff, we can see that the characters are portrayed in alignment with their roles in the story. For instance, the heroes are depicted with youthful features, such as large eyes, and are composed of short and smooth lines, as seen in the protagonist Simba. On the other hand, the villains are presented with sharp angles, dark chromatic palettes and large sizes, as seen in the antagonist Scar (Figure 31) (Artz, 2002). This work, Disney applies visual metaphors to convey information and make the narratives realistic, despite the story's fable-like nature.

Figure 31. Simba and Scar in “Lion King” (1994), by Roger Allers and Rob Minkoff.

In addition to fictional worlds, we are also interested in studying reinterpreted worlds in the genre of animated documentaries.

Animated documentaries are a curious genre because they use the same visual characteristics of animated fiction whereas via a non-mimetic expression of reality. To comprehend documentaries, we must grasp the concept of metaphors.

For this study we will classify metaphors as the experience of one thing in terms of another, that is, an abstract phenomenon translated by a concrete source. In Cinema, metaphors can manifest in various aspects, such as content, sound, editing, time, text, colour, speech and gestures (Hannibal, 2017).

An example of a documentary we wish to highlight is the pioneering short film “The Sinking of the Lusitania” (1918), by Winsor McCay. This film was the first registered animated documentary and recounts the events surrounding the sinking of the British ship Lusitania by a German war submarine during World War I, resulting in the loss of civilian lives. This film aimed to bring a previously non-existent portrait of what happened in the tragedy to the general public, serving as a means of appealing to the viewer to inform themselves about the event. Therefore, animated documentaries have the power to document the undocumented through the recreation of reality (Kalakh, 2022).

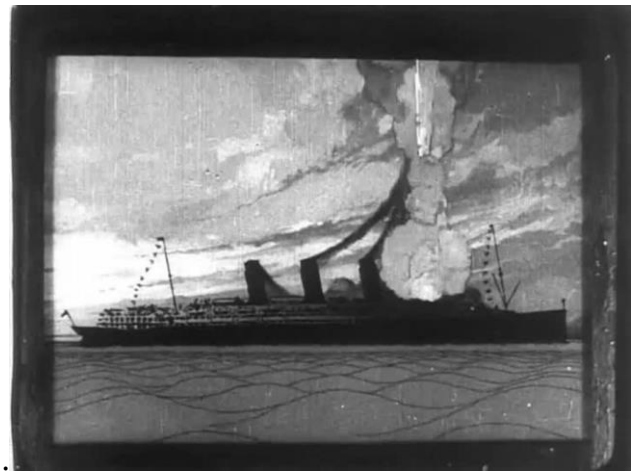


Figure 32. "The Sinking of the Lusitania" (1918), by Winsor McCay.

An animated documentary that that deserves recognition for its visual representation is the film “Persepolis” (2007), an adaptation of the autobiographical graphic novel by Marjane Satrapi. In this work, Satrapi uses exaggerated, stereotyped representations to create a dichotomy between East (Figure 33) and West (Figure 34), utilizing monochromatic black and white in opposition to coloured aesthetics to accentuate the contrast between cultures. In this film, the stereotyped presentation of the characters has a specific purpose, breaking down the separation between the Self and the Other, despite the work being autobiographical in nature (Hosseini, 2018).

Figure 33. Representation of the East in “Persepolis”, by Marjane Satrapi.

Figure 34. Representation of the West in “Persepolis”, by Marjane Satrapi.

When we talk about representing bodies in Animation, several noteworthy aspects come to light. In this medium, the body can be fluid, conditioned by modulations and remodulations. This is because of the representational capabilities that animation should never be considered an innocent, inferior medium or aimed at children. Paul Wells, in his work “Understanding Animation” (2013) states that an animation’s ability to portray socio-cultural themes increases awareness for the general public about marginalized groups, such as women and non-western, black, oriental or arabic people, as is the case in “Persepolis”. Through the representation of these groups in Cinema, the perception transmitted by the characters is of intimacy, and not of “otherness”. According to Wells (2013), animation portrays the body figuratively and symbolically, which often results in abstract pictures or shapes capable of being altered. Hence, Animation breaks the norms of traditional notions of gender, nationality and identity, enabling a radical and ambivalent vocabulary.

A short documentary film that uses animation to break social norms and show a portrayal of gender identity and sexual violence is the film “Your name is” (2021) by Paulo Patrício. This film tells the story of the murder of Gisberta Salce Júnior, a

transgender Brazilian woman, homeless and drug addict, who was brutally tortured and killed by a group of teenagers in Portugal in 2006. This film uncovers the story of this woman through interviews with her friends and two young individuals involved in the case. This work is an example of how Animation manages to display the reality of controversial and carnal themes, and still showcase different points of view.

In an interview with Patrício (Félix, 2022), the director explains that the film was designed to feature live-action footage and animation. However, as the individuals involved did not wish to be recorded, the film became fully animated. For this reason, the characters portrayed are graphically distant from the real people they represent.

Figure 35. "Your name is" (2021), by Paulo Patrício.

Diverging from documentary and venturing into fiction, next we will talk about the short film “Altötting” (2020), by Andreas Hykade. This film uses visual disparities to separate two diegetic worlds: the human world and the divine world. “Altötting” follows the story of a boy who, after being taken by his mother to a chapel, meets and falls in love with the Virgin Mary. It portrays their love over the years until he uncovers the disturbing source of the woman's beauty. Realizing that the Virgin maintains her youth by taking lives, he falls out of love with her.

In this film, the human world is represented by straight, minimalist and monochromatic lines, lacking details (Figure 36), and the divine world has a rich chromatic palette and uses dynamic and detailed strokes to show the figure of the Virgin Mary and those who enter her world (Figure 37). The film ends with the destruction of the divine world, when the Virgin Mary decides not to kill her lover, resulting in her own death. As the film ends, the boy leaves the convent and the sky of the human world, once monochromatic, gains colour. From the perspective of an ordinary mortal, this film is rife

with metaphors pertaining to the concept of divinity until the protagonist ultimately renounces religion.

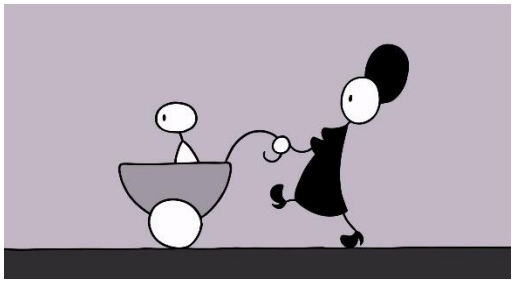


Figure 36. Human world in "Altötting" (2020), by Andreas Hykade. Figure 37. Divine world in "Altötting" (2020), by Andreas Hykade.

Lastly, “Black Soul” (2000), by Martine Chartrand, is a short film that harnesses the potential of animation and cinematographic montage to narrate the story of Black culture. This narrative is told from the point of view of a grandmother and her grandson, spanning centuries to depict their cultural heritage, from the reigns of their ancestors' kings and pharaohs to the era of slavery and their subsequent migration to the Americas. Set in Canada, where the family lives, the boy visits the memory of a past marked by slavery and struggles for freedom, but his grandmother shares with him the Martin Luther King's dream of equality, and the boy leaves the house to make a snow sculpture and shapes a figure that reminds him of his history (Chartrand, 2014).

The aesthetics of this film are stylized and dynamic, with lines moving freely and sometimes abstractly, and the chromatic palette varies according to the content of the scene. Its narrative, complex and laden with semiotic codes, is ordered chronologically and combines principles characteristic of fiction Cinema, which experimentally develops the visual aspect, and documentary Cinema, which seeks to explores the visual aspects while seeking to capture reality within a constructed setting, utilizing representation stereotypes to convey embodiment.

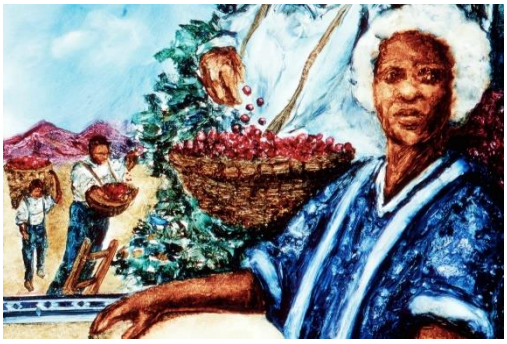


Figure 38. "Black Soul" (2000), by Martine Chartrand.

4.2 Animation as a Material Practice

In the realm of artistic creation, the choice of materials must correspond to the concept and solution of the work, aiming to captivate the spectator's aesthetic and emotional senses (Mogilevtsev, 2016). The materials an animated film uses become a metaphorical medium, as exemplified in Ann Marie Fleming's short film “I was a Child of Holocaust Survivors” (2010). The film utilizes visuals that symbolize the fragile nature of Holocaust memory, employing contrasting compositions that fluctuate between density and emptiness, characteristic of sketchiness, as well as varied textures.

This aesthetic is used to transport the viewer into the different spaces of the narrative, with the outside world presented by thick monochromatic lines and flat backgrounds (Figure 39); the character interactions presented by black backgrounds and white line figures (Figure 40); and the character's experiences and interpretation of the Holocaust presented by white backgrounds and colours (Figure 41). In this way, this film intends to distance itself from documentary images and uses animation to demonstrate a subjective truth of the events (Walden, 2014).

Figure 39. Still from "I was a Child of Holocaust Survivors" (2010), by Ann Marie Fleming. Figure 40. Still from "I was a Child of Holocaust Survivors" (2010), by Ann Marie Fleming. Figure 41. Still from "I was a Child of Holocaust Survivors" (2010), by Ann Marie Fleming.

In this way, the film portrays post-memory[8] by highlighting the dissonance between the animation's fantasy and the reality of the impressions these images leave on the observer's psyche. Similarly, the use of tangible and three-dimensional materials serves a similar purpose. According to Wells (2014), when Animation uses objects and materials, they can be created, manipulated, interpreted and dramatized, which alters their meaning, dramaturgy and status within the narrative. Notably, when Animation uses objects, these values are only considered when they are in motion. In this way, the objects express both tactility and substance, which elevates them in their reality compared to CGI creations. It is because they exist in reality that objects often lead to the fantasy that they have a life of their own, which is only possible due to our associations through touch and tactile memory. Accordingly, animators find it easy to visualize an object and attribute emotions to it.

To substantiate our claims, we decided to analyze our experience teaching a stop-motion workshop to students, both those with and without prior animation experience, and how the choice of materials influenced their performance as animators.

4.2.1 Traditional Animation vs Stop-Motion Manipulation in a Workshop with Children

While lecturing the workshop "Oficina de Stop-Motion" for students of the seventh and eighth grades from Agrupamento de Escolas D. Afonso Henriques, Santo Tirso, in the context of the project "INSERT - Estratégia Educativa Digital para uma Literacia Fílmica Inclusiva e Flexível", developed by CITAR of the School of Arts from Universidade Católica Portuguesa, we were given the chance of working with students between the ages of 11 and 13. The goal of this workshop was to make a small animated sequence with any material the groups chose. The first class was divided into two groups of four (Group 1 and Group 2) and two groups of five (Group 3 and Group 4), while the second class comprised two groups of ten students (Group 5 and Group 6). The first class

[8] Concept that, according to Hirsch (2008), describes the relationship that a generation has with events that preceded their births, but that are transmitted to them by stories, images and behaviors of those around them, creating a "memory" that does not belong to them.

had twenty minutes to complete an animation, while the second class had forty minutes. The most commonly used materials were clay and cardboard painted with permanent marker and oil pastels.



Figure 42. Still from an animation made by Group 1. Figure 43. Still from an animation made by Group 2. Figure 44. Still from an animation made by Group 3.

In the first class, corresponding to the eighth grade, the groups had a shorter production time and created simple animations without fully exploring the materials' potential. Before the animation exercises, there was a theoretical introduction covering the concept of “frame” and showcasing examples of movement through pixilation, allowing students to understand the idea of movement by using their bodies. Each group predominantly used clay as the primary material, with static elements, mostly backgrounds, created through drawing. Due to time constraints, one group could not complete the exercise.

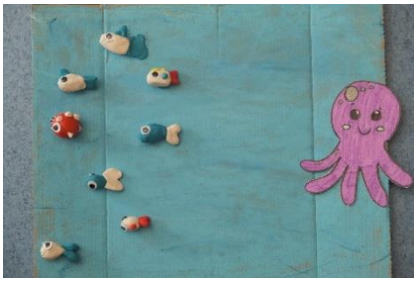



Figure 45. Still from animation made by Group 5. Figure 46. Still from animation made by Group 6.

In In the second class, corresponding to the seventh grade, the two groups, which had previous animation experience, had more time for the exercises, eliminating the need for a theoretical introduction. The class was divided into two larger groups. Unlike the first class, these groups did not use pre-colored backgrounds. The first group created 2D characters by hand-drawing them on paper and 3D characters using clay, while the second group exclusively used clay characters.

Throughout the process, it was evident that the student's ideas matured as they worked with the clay. Initially, the ideas in the first class lacked narrative or direction. These groups used their phones to photograph the animation frames, and we encouraged them to add more elements and characters. However, due to time constraints, the characters remained simple but well-animated. The storylines were created around the characters, such as clay worms escaping from a jar and forming a heart shape (Group 1), two snowballs colliding and running over a dog on a snowboard (Group 2), and a worm entering an apple on a cloudy day (Group 3).

In the second class, the groups decided on the stories before starting the production, drawing inspiration from music videos or previous class activities. However, as they began creating the characters, the stories evolved. Group 5 initially intended to create a fish transforming into a human, based on a music video they had watched, but the process of making the fish was so enjoyable that each group member created their fish, and the idea of transformation was abandoned. Additionally, two students in this group also worked on a 2D traditional octopus and starfish, initially hesitant to draw them, while the rest of the group created a clay mermaid and painted blue cardboard as the ocean's bottom. During the animation, the fish and mermaid were favored for movement, and the 2D drawings were the easiest to animate. The final storyline revolved around an “under-the-sea parade”. Group 6 aimed to create an animation featuring a meteor, building on a previous class activity. While crafting the meteor, they experimented with different materials for the surrounding fire, using both clay and cardboard. Ultimately, they chose to use clay exclusively for the meteor, while other elements were crafted from cardboard. Although this class presented the most creative proposals, their animations lacked fluid motion despite their prior experience and additional time available.

Through this experience, it became evident that tangible 3D materials, particularly cardboard, and clay, enhanced the students' creativity and facilitated the design of complex motion sequences. In the first class, clay was the primary material for animations and characters, resulting in better motion results. In the second class, clay and paper were primarily used, but there was less movement in each frame due to the challenges of creating motion with paper characters.

Peres Mesquita's (2022) study on creativity in children supports the notion that children possess greater creativity than adults but face challenges in realizing their ideas.

Furthermore, young individuals tend to integrate different artistic areas, with storytelling often intertwined with their drawings. This study also emphasizes the importance of engaging students in the creative process, highlighting the relevance of the student's body interaction with their visual production. For instance, children often use their bodies to gesture the movement while drawing, and tactile sensation aids in processing haptic, kinaesthetic, and proprioceptive information. Based on our workshop experience, the first class, which had no prior animation experience but received an introduction through pixilation examples, exhibited the best performance in terms of movement. Drawing upon Peres Mesquita's theory, when children use their bodies to mimic movement, it becomes internalized, minimizing the discrepancy between representation and reality (Matthews, 2003).

5 Synaesthesia and Stop-Motion Animation

In this chapter, we will leverage the knowledge we have acquired on synaesthesia, corporeality, the haptic, and other animation cinema concepts related to tactility. We aim to establish bridges between these concepts to prove our theory about how stop-motion animation, which we will define and explore below, and the art produced by biofeedback interfaces, which will be the focus of the next and final chapter.

5.1 What is Stop-motion animation?

Stop-motion is an animation technique in which objects are photographed frame-by-frame and moved through photographs and manipulated between each shot, creating the illusion of movement when the frames are played sequentially (Maselli, 2018).

Shaw (2017) defines stop-motion not only as a technique but as a form of expression in which the animator becomes the character and makes it live and feel to bring it to perform. Regardless of the medium, animation revolves around movement and the expression of emotions, and stop-motion specifically employs analog and typically three-dimensional characters and elements.

This technique has been part of the history of Cinema since its origins, and, at the end of the 19th century, filmmakers such as Georges Méliès transitioned from live-action filming to the realm of stop-motion to bring magical tricks to life on the big screen, as depicted in the short film "The Black Imp" (1905) where a group of chairs chases the main character.

Figure 47. "The Black Imp" (1905) by Georges Méliès.

This fundamental principle of shaping frames has remained the basis of stop-motion animation, which later evolved at both cinematic and narrative levels. Even before cinema cameras reached the hands of the pioneers like the Lumière brothers and Méliès, the models of stop-motion were already present in centuries of exploration with optical toys (Purves, 2010). Although this technique began in the history of Cinema with the intent of being a special effect, it quickly progressed to be present in the narrative of films, for example in the short film “Bewitched Matches” (1913) by Émile Cohl, when a set of matches turns into a skeleton and dances.

Figure 48. "Bewitched Matches" (1913) by Émile Cohl.

The most recognizable practices of this art include puppet animation, animation with found objects, pixilation, Claymation and animation with figures that use armatures and latex coating.

Puppet animation is a three-dimensional animation technique that features models of figures that resemble the puppets used in Theater (Dobson, 2020), was most prevalent in Europe and Asia because it evolved from traditional storytelling methods, as we can see in the short film “Ideál” (1964), by Bretislav Pojar (Figure 49). Although this technique has been widely explored in the East, puppet animation was a cultural phenomenon, and in the 1950s it was already present on American television (Priebe, 2010).

Figure 49. "Ideál" (1964), by Bretislav Pojar.

Animation with found objects resembles animation with puppets in that the animator has to manipulate these materials using a similar mechanism. The most noticeable difference between these two techniques is that, as the name implies, animation with found objects is performed with mundane everyday materials and its operation is more intuitive and low-cost (Nicholas & Paulos, 2022). An example is the short film “This Unnameable Little Broom” (1985) by the Brothers Quay.

Figure 50. "This Unnameable Little Broom" (1985) by Brothers Quay.

Pixilation, a technique that consists of photographing the movement of a person or piece of furniture frame-by-frame. In this technique, animators can use elements normally associated with live-action, but with a graphic rather than photographic aesthetic (Beaver, 2006). An example of this is Dave Borthwick’s” The Secret Adventures of Tom Thumb” (1993), which combines pixilation with puppet animation.

Figure 51. Dave Borthwick's "The Secret Adventures of Tom Thumb" (1993).

Claymation is also a three-dimensional technique in which the figures are moulded using clay. However, plasticise can also be used, and because it is an oil-based clay that does not dry easily, it is easy to model (Dobson, 2020). One notorious example of this technique is the feature film “Mary and Max” (2009), by Adam Elliot, in which clay was used to give the characters an aspect that was described as “homely at best and repugnant at worst” (Yahnke, 2013:2);

Figure 52. "Mary and Max” (2009), by Adam Elliot.

And, finally, animation with figures that use armatures and latex coating, resulting in characters with more realistic movements compared to other forms of animation. This technique originated from Ray Harryhausen's ground-breaking work and exerted a significant influence on the fantasy and science fiction genres (Shaw, 2017). An example of this way of modeling characters is the skeletons in the film “Jason and the Argonauts” (1963), by Harryhausen himself.

Figure 53. "Jason and the Argonauts" (1963), by Ray Harryhausen.

5.2 Synaesthesia and Haptics in Animation

As discussed in previous chapters, synaesthesia occurs when cross-sensory experiences originate from a single sensorial stimulus. For this chapter, we want to further investigate the synaesthetic process for non-synaesthetes, which are provoked by evocative metaphors and not by a neurological condition (Hatton, 2013). This distinction is crucial as we aim to examine the synesthetic metaphors in films that elicit immediate associative reactions of overlapping senses.

In Cinema, synaesthesia is an important characteristic of the spectator's experience, and, together with haptic aesthetics, it is possible to create immersion and engagement. By itself, the haptic is a mediation between our body and what we observe, and the skin ceases to be a barrier in the experience. This means that the synaesthesia that relates to our perception and vision provides information for our nervous system to have a haptic and extra-visual comeback (Fisher, 2003).

According to Quiroga (2013), the concept of haptic emerges with Deleuze (2011), when the author theorizes that Cinema creates a spatial notion in which vision is not only optical but also experienced through the senses of touch. Marks' idea of haptic visuality echoes Deleuze's logic by saying that haptic perception distances itself from optical perception. In Marks' (2000) theory, haptic perception is rooted in proximity, emphasizing the material presence of the image, as it is illustrated by Figure 51. In this way, Marks apprehends that cinematic spectatorship is an act of cultural translation, in which the spectator completes the meaning of the film through symbols originating from cultural codes and memories. Haptic visuality, in this way, functions as an empathic and

immediate understanding of an image through the tactility of that image and its inter-sensory effect between vision, memory, and the body.

Figure 54. "Frame enlargement from Chimera" example in Marks (2000). 1827 photography by Joseph Nicéphore Niépce.

For this chapter, we want to focus on synaesthesia and haptics in Animation Cinema, as a way of exploring how these characteristics influence the narrative, aesthetic, and the audience. Although synaesthesia is still relatively unexplored in the realm of moving images, certain genres acknowledge and utilize synaesthesia as an essential spectrum for comprehension, particularly abstract Cinema and visual music. However, the synaesthesia we find in Cinema is often limited and does not develop the relationship between the film and the viewer's perception to facilitate the apprehension of multiple simultaneous senses (Taberham, 2013).

5.2.1 Vision-sound Synaesthesia

The concept of visual music (Buteyn, 2011) emerged in the wake of technological advancements in the 1920s when synchronized sound became possible in moving images. Two pioneers of this art were Hans Richter and Viking Eggeling, with works such as "Rhythmus 21" (1921) and "Symphonie Diagonale" (1923), respectively.

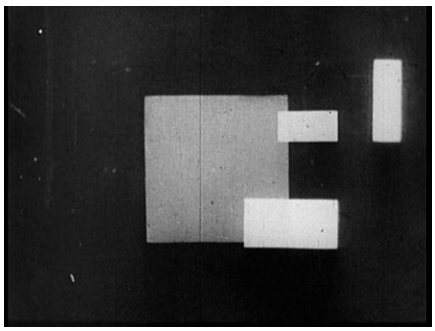



Figure 55. “Rhythmus 21” (1921), by Hans Richter. Figure 56. “Symphonie Diagonale” (1923), by Viking Eggeling.

However, it was not until that Warner Bros released the first live-action sound feature film, “The Jazz Singer”, in 1927, that synchronized sound technology became prevalent in most cinematographic productions. Following this development, more filmmakers of abstract Cinema started working with sound and music. Notable examples include Oskar Fischinger's “Allegretto” (1936) and Len Lye's “Free Radicals” (1958).

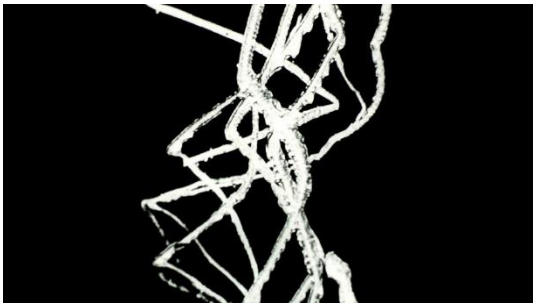



Figure 57. “Allegretto” (1936), by Oskar Fischinger. Figure 58. “Free Radicals” (1958), by Len Lye.

Throughout the 20th century, sound technologies in Cinema continued to evolve, even leading to recent abstract works with microsonic audio, such as John Whitney’s “Permutations” (1966) and Brian O'Reilly's “Point Line Cloud” (2005), a collection of audio-visual collaborations between Curtis Roads and O'Reilly,

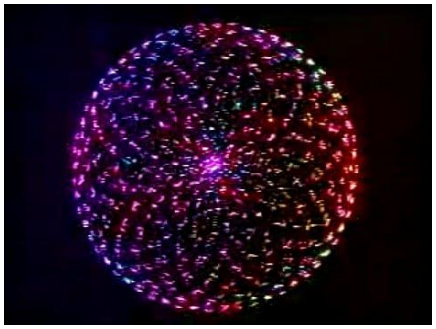
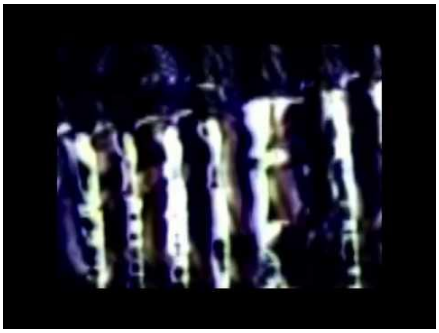



Figure 59. John Whitney's "Permutations" (1966). Figure 60. "Point Line Cloud" (2005), by Brian O'Reilly.

One iconic director of abstract animation cinema, Norman McLaren, used Animation as a surreal form of expression that could be interpreted as a demonstration of the director's subconscious, in response to the director's ideology and sexual identity. Two of his films that explore this manifestation of the director's inner life are "Dots" (1940) and "Loops" (1940), which use abstract life-like forms that converge, transform and interact with each other (Robusti, 2022).

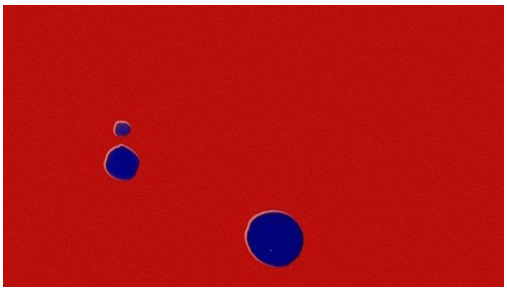
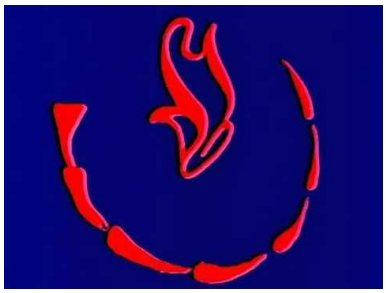



Figure 61. "Dots" (1940), by Norman McLaren. Figure 62. "Loops" (1940), by Norman McLaren.

To create a cross-sensory experience in these films, directors often considered various characteristics of the non-objects or elementary forms they employed, such as alignment, size, color, position, and movement, and how to relate and adapt these elements to the accompanying music (Haverkamp, 2010).

The characteristics of the musical structure also had to be applied to the film structure including repetition, juxtaposition, and variation. Therefore, while rhythm is significant, it is the creation of metaphors between the music and film structure that establishes a cohesive connection (Arfini, 2013).

5.2.2 Flavour-to-vision Synaesthesia

Despite vision-sound synaesthesia being the most documented forms in Cinema and being present in productions since the introduction of sound in films, there are more forms of synaesthesia to be explored and registered, not only in abstract Cinema but also in the mainstream.

One of these forms is flavour-to-vision synaesthesia, which appeared in popular culture after its prominence in the feature film "Ratatouille" (2007), directed by Brad Bird and Jan Pinkava and produced by Pixar Animation Studios (Wu & Gingrich, 2020). In the film, there is a scene where the main character, Remy, tastes different foods and their combinations, and the audience witnesses his reaction in the form of music, abstract shapes, and colors. This sequence was animated by Michel Gagné, a synesthetic animator who experiences chromesthesia, associating colors with sounds (Paskin, 2016). Because of his condition. Gagné was invited to develop concepts on how tastes could be visually translated. After the concepts were reviewed by Brad Bird, the composer created the soundtrack based on the visuals (Gagne, 2007).

Figure 63. "Ratatouille" Conceptual Artwork. Figure 64. "Ratatouille" Final Compositing.

5.3 Haptics and Vision-Touch Synaesthesia

In this dissertation we want to study synaesthesia by association, however, following the theory of Paul Schilder (1950), the senses are generally synesthetic. In this theory, the psychoanalyst argues that we apprehend senses simultaneously and that the isolation of each sense is a secondary process. This is something we can recognize in the theory of Kinetic Synaesthesia.

Kinetic synaesthesia is when visually perceived movement is perceived kinaesthetically. This results in a form of vision-touch synaesthesia are present in dance,

moving image and multimedia, allowing a tangible perception of the images. It is through kinetic synaesthesia that artforms such as Dance and Cinema, especially experimental modalities that do not follow a linear narrative that can distract the audience from sensory experience, use variations and movements to create the dynamic tension. Although kinetic synaesthesia is present in kinaesthetic, both being “sensory impressions of an eminently subjective nature” (Boucher, 2013), its experience is complex and can be difficult to interpret for all spectators.

One example of this form of synaesthesia is Merce Cunningham’s piece “Biped” (1999), that uses moving images and dance. This work consists of the non-continuous projection of animated movements and abstract geometric shapes captured by live motion capture of the choreography. As the dancers perform in the foreground, a projection of their movements follows in the background, establishing a strong kinaesthetic relationship between the moving bodies, the projected image, and the perceptual space in between. This interaction between movements and constant stimuli exemplifies what Boucher defines as kinetic synaesthesia.

Figure 65. Merce Cunningham’s “Biped” (1999).

To create a dynamic audio-visual experience, compositions must establish strong synesthetic connections, not only to move beyond a physical and cognitive interpretation to a spiritual one but also to enhance Cinema's ability to harbour metaphors (Gadassik, 2013).

5.3.1 Haptic Cinematography

The use of movements to evoke emotions or create ambiance is called “haptic cinematography” by Danieau (et al., 2014) This concept involves employing cinematic

techniques to stimulate the haptic sense. However, the author also emphasizes the existence of a Semantic Model (in contrast to a Cinematic Model) within which this cinematographic technique is reproduced through metaphors. In practical terms related to camera movements, the Cinematic Model aims to make the viewer feel the camera movement and the Semantic Model aims to evoke the effect of camera movement, for example using a diagonal shot (commonly known as "Dutch Angle") to indicate that something abnormal is happening. The Semantic Model comprises discrete narrative elements such as camera movements, editing, sound, and context (Guillotel, et al., 2016).

Two examples of animated films that employ the Dutch Angle, and belong to the Semantic Model are "Spirited Away" (2001), by Hayao Miyazaki, and "Wolfwalkers" (2020), by Tom Moore and Ross Stewart.

"Spirited Away" tells the heroic story of a child named Chihiro, following her individual growth throughout the film while performing universal human actions, such as working and caring for her loved ones, while in a world of monsters and spirits. The first scene of the film, which introduces Chihiro, uses the notorious Dutch angle (Figure 66). This choice was made to convey Chihiro's lack of interest in everyday elements and immaturity, but also her childishness and fragility as she has just woken up in the backseat of the car (Wu, 2016).

"Wolfwalkers", the last film in the Irish Folklore trilogy created by Tom Moore, is set in the British occupation of Kilkenny and tells the story of Robyn, an English girl, as she explores the Irish countryside and metamorphoses into one of their folklore creatures, a wolfwalker (Hargrave, 2021). In this film, the forest and its creatures are represented by expressive and loose lines, while the city and its citizens are represented by symmetrical and geometric lines (Sánchez Villar, 2021). After Robyn becomes a wolfwalker and befriends Mebh, Robyn's father captures Mebh's mother, which results in a conflict between Mebh and him. For this reason, when the confrontation between the two cultures takes place in the scene, the use of a Dutch angle is relevant because, in addition to indicating that something abnormal is happening, it is also distorting the lines of the city that should have a rigorous, symmetric composition (Figure 67).


Figure 66. "Spirited Away" (2001), by Hayao Miyazaki. Figure 67. Frames from the film “Wolfwalkers” (2020), by Tom Moore and Ross Stewart.

Next, we will emphasize the importance of the haptic within the narrative. While diegetic elements (belonging to the story space) and non-diegetic (not belonging to the story space) are commonly related to sound, notwithstanding their presence in every sound film, we are interested in studying the connotation of haptic effects in Animation.

The use of a diegetic haptic refers to the physical effect directed at a character or action, such as an impact, collision, or movement. One example of this effect is in “The Hand” (1966), by Jiří Trnka. This film, conceived using the puppet stop-motion technique, tells the story of a potter who makes vases until a white glove enters his house and forces him to make a sculpture of itself. One of the actions in this film that occurs from a diegetic haptic is when after the potter refuses, the glove locks him in a cage and forces him to create the sculpture (Figure 68). Through the use of puppets that deviate from human form and the creation of an anatomically correct hand, this surreal scene exists between the real and metaphysical aspects of the film (Cruz, 2020). This concept is only possible through the distortion of reality and not its denial, which is why the relationship of corporeality that we have by experiencing the film from the character’s point of view, and the physical efforts of the character to assemble an anatomical hand is essential for achieving embodiment and the concept of metaphysics.

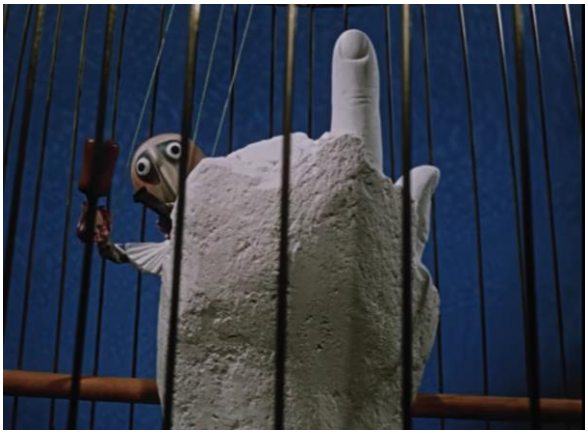


Figure 68. “The Hand” (1966), by Jiří Trnka.

5.4 Stop-motion animation and bodily perceptions

As demonstrated in Trnka's short film “The Hand”, stop-motion can yield visual results that awaken new diegetic possibilities in Cinema. In the following section, we will delve into the characteristics and techniques of stop-motion animation, encompassing both traditional and expanded forms. However, we will not make a distinction between which of the case studies fall into the spectrum of traditional or expanded cinema, as our aim in exploring forms of cinema beyond the conventional screen is to conduct a comprehensive analysis of the haptic potentials inherent in the technique of stop-motion. Nevertheless, it is important to define our understanding of expanded cinema following Youngblood (1979), when the author notes:

> When we say expanded cinema we actually mean expanded consciousness. Expanded cinema does not mean computer films, video phosphors, atomic light, or spherical projections. Expanded cinema isn't a movie at all: like life it's a process of becoming, man's ongoing historical drive to manifest his consciousness outside of his mind, in front of his eyes. (Youngblood, 1979: 41)

An example of an expanded animation practice is the work “The Great War” (2014) by the company Hotel Modern. This production consists of the creation of a “live animation” piece. In this concept, performers manipulate objects on a table on the stage while using a camera to film these moving objects, which are then projected behind them in real-time. Consequently, despite the objects being inanimate and the performers

appearing in the image, the combination of narration, sound, and the *mise-en-scène*[9] of the projection make the experience immersive due to the omniscience and omnipresence of the spectator within the space (Donelan, 2015).

Figure 69. Performance of "The Great War" by Hotel Modern (2014-06-02/2014-06-29).

5.4.1 Stop-motion and vision-touch synaesthesia

In our exploration of the tactile implications of the stop-motion technique, we have discovered that stop-motion serves as a medium that embodies the concepts of haptic visuality, cinematic tactility, and an embodied cinematic experience. This is because this technique challenges the notion of materiality, fabrication, tactility and tangibility, and requires the animator's touch and triggering of the audience's tactile memory (Yekti, 2021).

A director whose work is fundamental for this study is Jan Švankmajer. He states that the body is what registers and perceives the world, yet, touch has become dependent on vision, which results in what the director calls "false synaesthesia" because touch and vision have become dependent rather than simultaneous independent sensations (Becker, 2023).

Švankmajer creates cinematographic works that explore touch in a poetic and metamorphic way rather than just phenomenologically. These films usually use different

[9] Mise-en-scène is a term that originates in the Theater and refers to the contents that are on the stage and in their arrangement. In Cinema, it refers to the contents belonging within the frame and that will give the audience visual information about the diegetic world of the film (Kuhn & Westwell, 2012).

stop-motion animation techniques, with puppetry being the predominant approach (Vasseleu, 2009).

Švankmajer's work is centered around the ideal that touch is the most vital sense, and that it goes beyond the hands, which he considers his tools. Notwithstanding, he believes that the hands are not the most important tactile organ, as the most important parts are the passive, like the cavities, membranes, surfaces and internal organs. Through his surrealist practice, he employs animation to express his broadest sense of tactile capacity.

In the work "The Fall of the House of Usher" (1982) this objective is clear, as the director repeatedly uses close-up to emphasize the details and textures of the surfaces and presents them in black and white to reject colour as the most immediate stimulus (Powell, 2016).

Figure 70. "The Fall of the House of Usher" (1982) by Jan Švankmajer.

We can also see these characteristics in the short film "Passionate discourse" (1983), from the series "Dimensions of Dialogue" (1983), which tell the story of two lovers who, because they are unable to communicate with each other, have their carnal passion turn into violence. The film employs claymation, so that the characters are built and deconstructed according to their actions and emotions (Hagemann, 2012).

Figure 71. "Passionate discourse" (1983) by Jan Švankmajer.

5.4.1.1 "Body as matter"

For our study, we find it relevant to highlight Corso's (2022) discoveries with the dissertation "Pele como Suporte, Sangue como Tinta: Um Estudo sobre o Embodiment num exercício de Animação Experimental", for the reason that this dissertation also studies the influence and impact of the body in the creation of animation cinema. In this, the author studies how experimental animation has an impact on the body and senses, not only on the spectator but also on the animator. Following Sobchack's theory (2004), she argues that embodiment is present in all human experience, proving that the body is the centre of our perception of reality. She furthermore states that bodily knowledge is the most intrinsic among humans, as every human has a body. In this perspective, the analysis of the spectator's corporeality[10] is essential to value the representation, production, and perception of the body in animation, as well as the use of the body as matter.

Corso's study highlights various animation methods within the realm of experimental animation that emphasize and enhance corporeality. The most significant techniques to explore in relation to our theory are Animation with Found Objects, Puppets, and Cut-out. Additionally, Corso recognizes the "Body as matter" as a form of representation, which employs techniques such as pixilation and the utilization of skin as a medium. In both approaches, the body is appropriated as matter and the relationship between the work and the spectator comes from the mimesis of identifying one's own body with what one observes.

[10] We also want to clarify that not all humans are able to feel their bodies. There is a clinical case documented by Sacks (1987) in "The man who mistook his wife for a hat and other clinical tales" which accompanies the case of a woman who lost her sense of proprioception due to acute polyneuropathy.

5.4.2 Case studies

From the animation methods highlighted by Corso (2022), we will analyse examples whose aesthetic and narrative characteristics go against haptic, diegetic, or non-diegetic visuality and narrative.

5.4.2.1 Found Objects

One example of animation with found objects is the short film “Flesh” (2019) by Camila Kater.

“Flesh” is a documentary that explores the stories of five women as they recall significant episodes from their lives, spanning from childhood to old age. In this film, different techniques are used to illustrate what the narrators are describing. For instance, there is a scene where a girl runs on a plate while the narrator explains how others perceived her body. Eventually, the girl stops, and the plate shatters into pieces, creating a diegetic haptic sensation through action.

Figure 72. "Flesh", by Camila Kater, found objects sequence.

5.4.2.2 Claymation

As this documentary also employs different techniques accordingly to the story that is being portrayed, there is also a claymation sequence that depicts a woman's experience of her body during menopause.

Figure 73. "Flesh", by Camila Kater, claymation sequence.

5.4.2.3 Puppet animation

Another example of animation with puppets, apart from the ones we have already examined throughout the chapter, is the short film “Negative Space” (2017), by Max Porter and Ru Kuwuhata.

“Negative Space” is a short film about the relationship between father and son. While the film predominantly focuses on mundane elements such as clothing and travel objects, the puppets used in this film are meticulously crafted to resemble everyday objects. The textures of the objects were carefully reproduced to achieve a realistic effect, making the film successful in evoking a haptic and illusory perception.

Figure 74. “Negative Space” (2017), by Max Porter and Ru Kuwuhata.

5.4.2.4 Cut-out

Furthermore, the short film "Inspector Street" (2013) by Emmanuelle Loslier exemplifies animation using the cut-out animation. Cut-out is a technique two-

dimensional that uses flat materials for its characters, which are usually created using paper, scissors and colours (Anumasa & Yadav, 2013). This technique is widely used in experimental animation and one of its main characteristics is the psychological immediacy that its forms provoke in the spectator, stimulating their imagination and immersion (Yuan, 2010).

"Inspector Street" follows a newspaper that, after being abandoned, has its pages come to life. In this film, photographs inside the newspaper move and form strange creatures, which eat letters, tear up pages and create a mess based on rage and madness. To fight the creatures, the pages of the newspaper are torn and crumpled, until the newspaper is nothing more than a set of white and perforated sheets.

There is a diegetic haptic in this film, as the tactility of the newspaper is part of the narrative in the form of collisions and actions that make the oddities of the newspaper almost tangible.

Figure 75. "Inspector Street" (2013) by Emmanuelle Loslier.

5.4.2.5 Pixilation

One example of animation with pixilation is the short film "Amélia & Duarte" (2015), by Alice Guimarães and Mónica Santos. This film tells a love story between two characters, from the moment they meet and fall in love, until they end the relationship and go separate ways. In this film, the characters' interaction with objects has an important role in the narrative. The technique of pixilation creates a barrier between the normal notion of movement and what our bodies can do, resulting in an immersion that suspends the spectator's bodies. This way, realistic locations and the characters' interaction with everyday objects enhance the immersive experience.

The laws of physics do not apply to this film, such as objects moving by themselves or characters walking without lifting their feet off the ground. Regardless, this distinction from the real-world ceases to be important as we watch the film and our touch organs get stimulated from the abnormalities of the diegetic universe. Not only our hands, but our whole body, just as Švankmajer believed the haptic stimulus should be.

Figure 76. “Amélia & Duarte” (2015), by Alice Guimarães and Mónica Santos.

5.4.2.6 Skin as a support

In the category of using skin as a support, there are two notable examples: “bEACH” (2020) by Declan McKenna and “Hey Pressto” (2017) by DBLG and Animade. Both films involve drawing on the skin to create an animated sequence.

The use of skin in animation is fundamental to understand the vision-touch synaesthesia that these representations can provoke. In “bEACH” it is drawn on the skin and in “Hey Pressto” a stamp is used to mark the skin through pressure.

Figure 77. “bEACH" by Declan McKenna. Figure 78. “Hey Pressto” (2017), by DBLG e Animade.

In addition to these films, we want to mention the experiment “bloodline” (2022) developed by Carina Corso. This experiment involves creating lines on the skin through tattoos without ink, resulting in an open and ephemeral wound where the trace is delineated in blood. This work further exemplifies the use of skin as a medium for animation.

Figure 79. "bloodline" (2022) by Carina Corso.

These forms, which we consider expanded because they go beyond the traditional, still have narrative potential. In “bloodline”, the narration is what determines the illustrations on the skin, creating a synaesthetic connection between the audio-visual elements (the tattooed image and narration) and the skin (which is the support of the image, the animator's manipulation and the viewer’s receiver).

In this chapter, we were able to identify forms of synaesthesia in animation film and explore how vision-touch synaesthesia is interpreted in this art to create new diegetic and non-diegetic meanings. The distinction we make between these two forms is that the haptic effect in the narrative diegesis arises from actions, explosions, and all elements that require an understanding of textures and surfaces, and the non-diegetic is when the haptic is present in camera movements, editing, sound, and context. In this way, we classify the diegetic haptic as part of the Cinematic Model and the non-diegetic as part of the Semantic Model.

Throughout the examples we presented, we gained insights into how the haptic dimension contributes to narrative experiences across various genres, including short fiction, documentaries, and experimental films. We noticed that, in these works, tangibility was not only related to the similarity between the hands of the audience and

the animator but with the entire body of the spectator, the animator, and the characters. In addition to traditional cinema formats, we were also able to study this effect in expanded cinema and experimental supports such as skin.

By applying the concepts of haptic and vision-touch synaesthesia to the realm of stop-motion animation, we can further investigate how biological information and embodied experiences can profoundly influence narrative and aesthetic dimensions. This exploration opens up possibilities for deeper understanding and analysis of the intricate relationship between tactile perception, audio-visual elements, and storytelling in animation.

6 Biofeedback and Animation: hypothesis development

With this dissertation, we were able to find connection points between the art created by biofeedback interfaces and the materiality of stop-motion animation cinema. The main characteristic that connects the forms of creation is synaesthesia, mainly vision-touch synaesthesia and haptics.

Initially, we could see that biofeedback is an instrument commonly used in medicine, whose primary function is to analyse the user's biological input and transform this information into a visualization of this signal, usually visual or auditory. In our research we found that, in addition to visual and auditory modes of exposure, there are also artists, researchers and scientists who use material and tactile means to convey this biological information. The use of physical models is considered effective as they employ spatial metaphors and three-dimensionality to facilitate comprehension. As the main objective of biofeedback is to enable what we understand as an awareness insight (data with the intent to give awareness to the user and not to reach any particular conclusion), the use of physical models proves to be effective, as these models work with spatial metaphors to create patterns that humans can understand due to association and spatial perception, in addition to these models also being described as more accessible due to the paradigms of interaction and navigation.

The way we understand an object when we see it has in common studies of aesthetics, design and interaction. It is crucial to emphasize this connection as well as how biofeedback has been interpreted in artistic creations, exemplified by works such as “Process of Fabrication of the Blood Flow Visualization Model” (Ang et al., 2019), “Wooden Brain” (Neil Fraser, 2008), and “Tattoo Biosensors” (Yetisen et al., 2019). By exploring these diverse materials, techniques, and viewer interactions, we establish a link between these objects and those used in narrative storytelling within animation cinema. Through our theory, we demonstrate that the “Data Objects” we describe share similar characteristics and possibilities with animated models.

To support our argument, we delved into the study of synaesthesia, defining it as a complex form of perception where information is simultaneously processed by different senses. Our focus primarily revolved around touch-related synaesthesia, as identified in literature (such as touch transferred to taste), painting (touch transferred to color),

interactive installations (Touch-screen synaesthesia), and cinema (highlighting the haptic as a means to understand objects beyond vision, both in works and apparatus).

Because this work focuses on Cinema, we decided to explore in particular how the haptic influences our filmic experience and how it shapes our perception of a work, since the haptic and the tactile quality of images have been present in film since its early days.

Throughout the history of Cinema, the relationship between the screen and the viewer, vision and touch, the eye and the skin, has been explored, not only by critics and theorists but also by artists. We can see this relationship portrayed literally in the works "The Cabinet of Dr. Caligari" (1920), by Robert Wiene, "Un Chien Andalou" (1929), by Luis Buñuel and Salvador Dalí, and "Orphée" (1950), by Jean Cocteau, through scenes that use contrasting camera shots of eyes, hands and mirrors. However, our focus lies in exploring the metaphorical portrayal of this relationship in films, examining for this study the feature film "Fight Club" (1999) by David Fincher, the short film "La ultima polaroid" (2004) by Mar Coll, and the animated feature film "Belladonna of Sadness" (1973) by Eiichi Yamamoto. These works employ techniques such as camera movements and textures to create a strong sensory experience for the viewer. In "Fight Club", the haptic dimension is used to emphasize sexuality and violence, while in "La ultima polaroid", the grainy texture of the imagery evokes nostalgia and ambiguity. "Belladonna of Sadness" utilizes haptic elements to transform the abstract into tangible sensations, employing textures and graphic elements to evoke tactile and metaphorical connotations.

Due to the innumerable possibilities of Animation Cinema, because of its ability to graphically represent imaginary worlds and different situations, the study of the spectator's perception of these representations is essential for artistic creation. And, in addition to this art being able to shape fictional worlds, there are also animated documentaries that follow the principles of animation and portray reality. In this way, Animated can approach different themes and develop concepts not only in its narrative but also visually. Thus, we chose to study animation as a material practice to examine the physicality of these works and their perception in relation to biofeedback and the translation of information through touch and vision.

Through our study of animation as a material practice, we have drawn several conclusions: the choice of materials should align with the concept and purpose of the

work, appealing to the aesthetic and emotional senses of the viewer. When animation incorporates objects and materials, they can be created, manipulated, interpreted, and dramatized, altering their meaning, role, and narrative significance. Furthermore, the existence of objects and materials in reality often leads us to imagine that they have a life of their own, thanks to our associations and tactile memory.

To prove these observations, in this phase of the study we developed a stop-motion animation exercise with children from the D. Afonso Henriques School Group, in the context of a workshop. During the workshop, we noticed that the children found it easier to work with and manipulate three-dimensional materials and objects. Consequently, most of the groups chose these instruments over creating a two-dimensional animation. Through this workshop, we concluded that, despite time and experience limitations, the groups that achieved better animated movements were those that learned to perceive the movement of objects as an extension of their own bodies. This finding was significant as it highlighted the body as a medium for animation.

In the subsequent chapter, we studied the role of the body in Cinema, and how synaesthesia is an important characteristic for the spectator's experience, together with haptic visuality, because the haptic is a mediation between our body and what we observe. To examine the body in animation cinema, particularly in the context of stop-motion technique, we aimed to contextualize the concept of "haptic cinematography". This term refers to cinematic techniques that evoke the haptic sense, whether metaphorically (Semantic Model) or practically (Cinematic Model). Building on this foundation, we analyzed the interdependency between the bodies of animators, spectators, and animated characters or elements, as well as the pervasive sense of tangibility across various film genres and formats.

Within the context of different formats, we emphasized the significance of experimental and expanded works in cinema, in order to study how the animator and the spectator interacted and how vision-touch synaesthesia inhabited outside the traditional screen. As case studies, we examined various techniques within the stop-motion spectrum, including animation with Found Objects, Claymation, Puppets, Cut-out, Pixilation, and animations that employed Skin as a medium of expression. Through these techniques and the examples of films we have chosen, we observed that stop-motion is a

technique based on corporeality, and sometimes this relationship becomes a mimesis between the body of the observer and the body observed.

Regarding our hypothesis on the use of biofeedback to enhance animation cinema, we would like to highlight artistic cases that illustrate how animation has historically incorporated biological signals in storytelling. However, due to the lack of examples that directly relate biofeedback and Animation Cinema, we will start by addressing examples that feature biofeedback in animated videographic art. For this, we want to highlight the works "Biofeedback Artwork" by Amy Karl (2011), in which the artist connects her body to a Sandin Image Processor, in order to visualize on video the information of her body captured by the analog electrophysiological visualization device. The duration of the piece corresponds to the length of time the artist remains connected to the machine, documenting her unconscious bodily responses (Karle, [s.d.]).

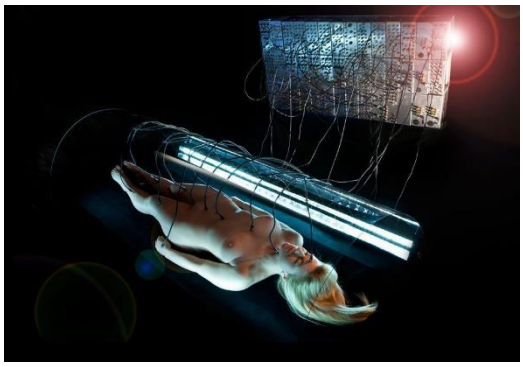


Figure 80. "Biofeedback Artwork" (2011) by Amy Karl. Photograph by Andre LaRoche.

The series "Cardiomorphologies", by George Khut (2004-2006), an interactive art project in which a large-scale video is projected and created in real time through changes in breath and heart rhythms, collected from sensors attached to the participant's body (Neumark & Khut, 2007).

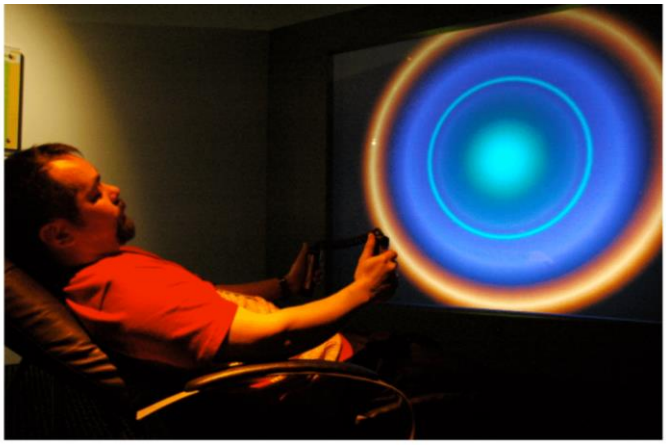


Figure 81. " Cardiomorphologies" (2005) by George Khut. Image property of Greg Turner.

"Measuring the Magic of Mutual Gaze", a work by Marina Abramovic that explores the concept of telepathy and reflects on our increasingly mediated world. In the 2013 presentation, the artist collaborated with the neuroscientist Suzanne Dikker to show their brains in moments of greater synchrony, through an animation made via an Emotiv EEG bioneuroheadset (Abramovic, 2016).

Figure 82. "Measuring the Magic of Mutual Gaze" (2013) by Marina Abramovic.

Furthermore, we find it important to highlight the animation exercises by Dina Amin (2022), shared on her Instagram page "@dina.a.amin." In these short videos, the animator creates animations using still images from medical exams, including her own Chest CT exam and her father's MRIs. The objective of these exercises was to provide them with awareness insights regarding their medical conditions through animation.

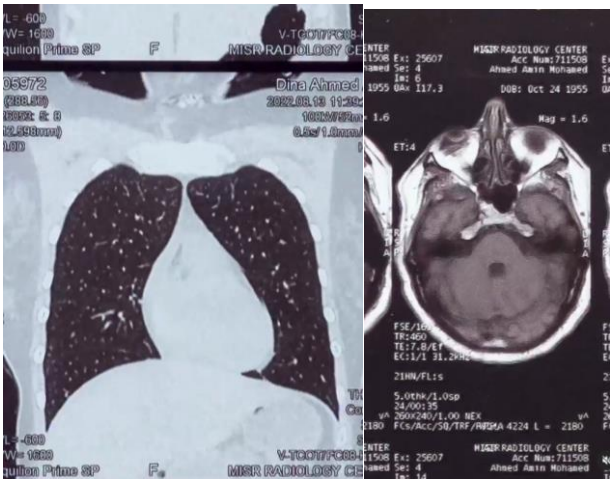


Figure 83. CT exercise still from Dina Amin (2022). Figure 84. MRI exercise still from Dina Amin (2022).

While examples directly linking biofeedback interfaces to animation cinema are limited, we can list some films and scenes that are animated and use biological data to enhance the aesthetics and narrative dimension of the film.

The examples we want to highlight are the short film “Tragic Story with Happy Ending”, by Regina Pessoa (2005), in which the main character is an outcast because she has a loud and fast heartbeat, reminiscent of a bird's. In this film, the sound of the heartbeat, as well as the movement of the chest, are essential elements of the narrative, as well as being what distinguishes the main character from the others and also marking the visual and auditory rhythm of the compositions.

Figure 85. “Tragic Story with Happy Ending” (2005), by Regina Pessoa.

“In a Heartbeat”, by Beth David and Esteban Bravo (2017), which tells the story of a closeted boy who runs the risk of being outed by his own heart when he sees the boy

who makes his pulse race. For this short film, the heartbeat serves as a metaphor for the inevitable and transparent love that the boy feels, being present both on a sound and visual level.

Figure 86. "In a Heartbeat" (2017), by Beth David and Esteban Bravo.

"Subconscious Password" (2013), by Chris Landreth, tells the story of a man who has trouble remembering his own name. In this short film, the imagery representing brain activity serves as metaphors for the exercise of memory.

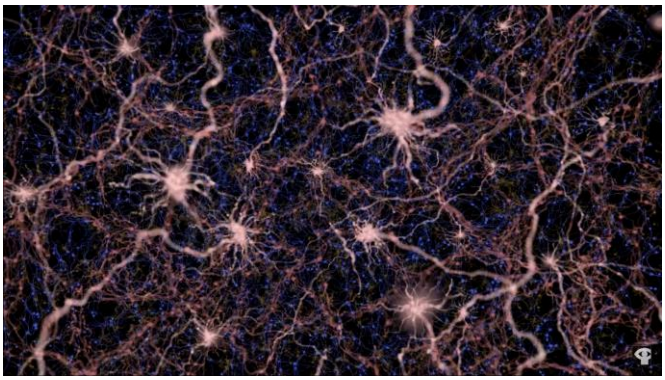


Figure 87. "Subconscious Password" (2013), by Chris Landreth.

"All Those Sensations in my Belly" is a short film by Marko Dješka (2020) that revolves around a transgender character navigating her love life while facing challenges in establishing relationships with men. In this film we can see representations of blood, mostly red globes surrounding the character, symbolizing the metaphorical connection between the character's described "strange energy" (Dješka, 2020, 3:02) and the role of her own body in the biological discomfort she experiences.

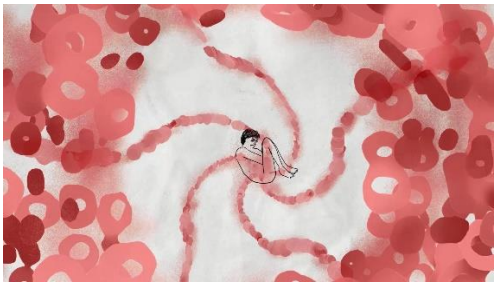


Figure 88. "All Those Sensations in my Belly“ (2020), by Marko Dješka.

Additionally, in the film “Pain and Glory” by Pedro Almodóvar (2019), there is a scene titled “Anatomy” that interrupts the narrative flow. In this animated scene, the director employs various medical tests to illustrate the protagonist's sensation of suffering, as he perceives his body as a burden to his existence. The scene conveys that the character is aware of his dependency on his physiology and, consequently, on his pain.

Figure 89. “Anatomy” scene from “Pain and Glory” (2019) by Pedro Almodóvar.

With this chapter, we aim to foster a dialogue between these two art forms—animation and biofeedback—which, despite their historical separation, share similar languages due to their graphic representations. We also want to emphasize the importance of creating physical representations through biofeedback, as this way of exposing data is more easily interpretable and inclusive, as we have been addressing. We believe that there are numerous unexplored possibilities for artistic practice that combine physical representations of biofeedback with stop-motion animation cinema, although we were unable to find any specific examples that merge these two fields.

7 Conclusion and Future Research

Regarding our main question “Can biofeedback be an interface to create materials for stop-motion cinema?” we have delved into the connection between the body in animation cinema, particularly in the context of stop-motion techniques. By incorporating biofeedback as an interface for artistic creation, animation creators have the opportunity to delve into the viewer's bodily sensations and perceptions, thereby crafting a more immersive and engaging cinematic experience.

In this way, the haptic qualities present in biofeedback interfaces enable a direct connection between the spectator's body and the observed objects, whether they are Data Objects with awareness insights or characters from an animated film, as both use haptic elements to allow for a deeper understanding and empathy with the characters or objects and their narratives or meanings. Additionally, the aesthetic advantages of biofeedback allow for the translation of biological data into visually captivating representations, expanding the possibilities of visual metaphors in Animation.

In light of our findings, it is clear that the incorporation of biofeedback as an interface has the power to transform the cinematic experience, making it more immersive, captivating, and emotionally resonant. Furthermore, the exploration of this relationship between the body, animation cinema, and biofeedback not only deepens our understanding of the medium but also highlights the potential for creating meaningful connections between technology, art, and the human body. As Animation continues to evolve, the exploration and use of biofeedback technologies have immense potential to push the boundaries of storytelling, aesthetics, and audience engagement.

Looking ahead, we have plans to do further research in the field of animation and biofeedback. These may include the development of practical projects, collaborative endeavours with other disciplines, and the investigation of specific case studies. Taking into account the conclusions of this work, we propose to, in the future, make a practical film project based on the findings of this dissertation, to employ data from the author's magnetic resonance imaging to create a stop-motion film.

In the documentary short film “Land in Sight” (2021), the author introduced medical images for the first time in her work and observed the impact this information had on the audience, as it brought them closer to her physical experience.

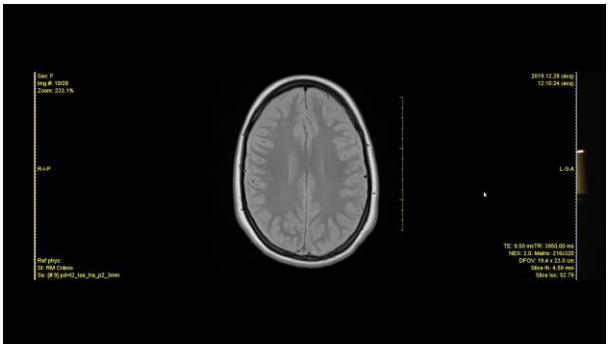


Figure 90. MRI still from “Land in Sight” (2021), by the author.

In the future, we suggest subsequently developing a film project that applies the research presented here, documenting the experience and outcomes. Additionally, we aim to publish the findings from this study to engage with the academic community and reach a wider audience, fostering debate and gathering different perspectives. By doing so, we hope to find new examples of animated films that use biological signals and medical exams, with a particular interest in exploring the possibilities within the stop-motion technique.

Likewise, we intend to develop a program for visualizing medical data, or work with an existing program, to convert its results into more aesthetically appealing visualizations. This would provide a space for visual experimentation and exploration of the artistic possibilities within the visualization of biofeedback.

We are also interested in continuing the study of the forms of synaesthesia that are present in Animation Cinema, as we would like to develop a detailed study on each of the filmic examples that have not yet been addressed in the academy, and continue to look for films produced by diverse groups, bringing to the discussion more films produced in non-Western countries.

Building upon the discoveries made in this dissertation, we plan to produce articles that expand upon the research findings. By delving deeper into these subjects, we can develop a potential doctoral project that encompasses the relationship between the spectator, technology, and art. With more time at our disposal, we would like to undertake activities such as creating visualization programs, engaging in artistic practice, conducting direct studies with a group of spectators, and engaging in discussions with colleagues from academia.

With this dissertation, we can conclude that the use of biofeedback as an interface opens new avenues for creativity, storytelling, and audience engagement in animation cinema. By further exploring the possibilities and implications of this relationship, we can push the boundaries of cinematic expression, create transformative experiences, and continue to advance the field of Animation.

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