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METAMORPHOSIS

EXPERIMENTS IN THE DESIGN OF INTERACTIVE MOVING POSTERS

Dissertation in the context of the Master's in Design and Multimedia, advised by Sérgio Miguel Martins Rebelo, Artur Luís Gonçalves de Azevedo and by Daniel Filipe Santos Lopes

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Metamorphosis: Experiments in the Design of Interactive Moving Posters

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To my parents, for unconditional support throughout my academic journey.

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Resumo

Nos dias de hoje, as pessoas são constantemente abalroadas por grandes quantidades de informação através de publicidade na rua, TV e até online. Por esse motivo, torna-se cada vez mais difícil desenhar artefactos de comunicação capazes de competir com os demais e de transmitir uma mensagem ao respetivo público alvo de uma forma eficaz. Para chamarem a atenção e serem absorvidos, os diversos artefatos de comunicação, como cartazes, têm vindo a evoluir ao longo do tempo, procurando formas mais atrativas de apresentar informação e transmitir mensagens. Por exemplo, animando elementos dos cartazes e exibindo-os em mupis digitais. Ainda assim, na era digital em que vivemos, os anúncios em movimento começam cada vez mais a ser uma constante, pelo que a batalha por atenção contínua e novas técnicas devem ser adotadas. Esta dissertação pretende explorar tecnologias digitais para criar cartazes mais atrativos e comunicativos. Nesse sentido, é apresentado um conjunto de cartazes interativos que alteram a informação exibida de acordo com as ações do espectador e os dados ambientais. Para conduzir os desenvolvimentos, trabalhou-se sobre o tema Metamorfose, mais especificamente, a atual metamorfose ambiental do planeta Terra. Os cartazes foram compilados numa exposição online para que fosse possível experienciá-los e interagir com eles. Por último, foram realizados testes de utilizador para perceber se as soluções propostas eram ou não mais eficazes do que formatos de cartaz existentes, como cartazes estáticos e cartazes animados. Embora os resultados devam ainda ser suportados por mais testes, estes sugeriram que a adoção de técnicas interativas pode ser uma solução viável para a criação de artefatos de comunicação mais atraentes e envolventes.

Palavras-Chave

Design de Cartazes
Design Gráfico
Design Algorítmico
Interação Humano Computador
Motion Design
Dados Sensíveis ao Contexto
Visão por Computador

Abstract

Nowadays, people are constantly being presented with large amounts of information from street, TV and online advertising. This fact makes it difficult for people to pay attention to all that information and even more difficult for graphic designers to make messages pass through over competing communication artefacts. To catch attention and be absorbed, communication artefacts such as posters have been changing over time, seeking more engaging ways of presenting information and passing messages. For example, by making posters moving and displaying these in digital mupis. Nevertheless, in the digital era, we live in, moving ads have already started to be a constant, so the battle for attention remains up and new engaging techniques must be adopted. This dissertation intends to explore digital technologies to create more engaging and communicative posters. In that sense, we present a set of interactive moving posters that display information according to the viewer's actions and environmental data. To conduct the developments, we have worked over the theme Metamorphosis, namely, the current environmental metamorphosis of the planet Earth. The posters were compiled into an online exhibition so one can experience and interact with them. Lastly, user testing was conducted to assess whether the proposed solutions were more effective over existing poster formats, such as static and moving posters. Although the results must be supported by further testing, these suggested that the adoption of interactive techniques may be a viable solution for creating more attractive and engaging communication artefacts.

Keywords

Poster Design
Graphic Design
Algorithmic Design
Human Computer Interaction
Motion Design
Context-aware data
Computer vision

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1. Introduction

Posters are one of the most well-established communication mediums and have played a key role in the transmission of information over time (Sontag, 1970; Meggs & Purvis, 2009). Their origin remotes to cave painting. Since then, posters have been constantly changing, evolving alongside technologies, but always keeping their same primary goal of capturing viewers attention to transmit a message and/or persuade to produce an action (Sontag, 1970).

During the Industrial Revolution (*c.* 1760 – *c.* 1840) and the Belle Époque (*c.* 1890 — *c.* 1900), posters turned into the preferential media for mass communication, *i.e.* for spreading a message to a larger audience in multiple environments and surroundings (Meggs & Purvis, 2011). Until then, the greatest concern to designing a poster was displaying the message in the cleanest way possible. However, mass communication led to an increasing amount of competing information on the streets, so graphic designers felt the need to start studying and designing posters to appeal to the viewer's eyes and catch their attention (Sontag, 1970).

From there on, there has been the increasing importance for posters to be more and more attractive and to communicate more and more straightforwardly, so they can compete over the increasing amount of information presented to people on the streets, not only through printed posters, but also through formats such as billboards, flyers and others. In recent times, this difficulty has also spread to the web, as more and more people started to create their own content and share it online (*e.g.* in social media).

This overwhelming amount of communication artefacts tends to lead people to disregard most of the information presented. For this reason, in communication design (such as posters'), there still is a constant need to find new design techniques/tools for aiding the creation of innovative solutions that better catch the public's attention and communicate more effectively.

Recently, to respond to the aforementioned necessity, digital moving artefacts such as video/animated posters or walls (or on the web, video/animated advertising) are starting to become one of the favourable media to compete in the battle for people's attention. However, as moving mediums start to be more and more frequent and common, other more engaging solutions still need to be endorsed.

In this dissertation, we explore the usage of interactive features as a way to capture people's interest and engage people with the issues transmitted by communication media (such as posters). Therefore, we seek to explore fields of study such as Graphic design (GD) Algorithmic Design, Human-computer Interaction (HCI) and Human-Centered Computation (HCC) to assess how different levels of dynamism can impact the communication of typographical messages, especially, through the poster medium.

To assess the proposed hypothesis, we present and test a set of interactive moving posters. To conduct the developments, we have worked over the theme Metamorphosis, more specifically, the current environmental metamorphosis of the planet Earth. Thus, the posters have the goal of bringing awareness to some of the problematic environmental issues of contemporary times. *i.e.* posters that communicate about the impact that the current human practices may produce on the planet.

To do that, each poster presents a different typographic message regarding one of the following subjects: Air Pollution, Biodiversity Loss, Deforestation, Global Warming, Noise Pollution, Waste and Water Pollution. Besides this main message, each poster includes additional elements, figurative or typographic, that refer to the respective addressed problem, and react to environmental data and the viewer's actions, in real-time. By taking advantage of digital technologies to gather and present information about the surrounding environment, we aimed to demonstrate to the viewers that the addressed issues are real issues that exist at the time and, sometimes, place that the viewers are in. Thus, in general contexts, we propose the use of such techniques to help raise awareness of local issues. Besides, by interacting with the posters (performing an action through movement or sound), the viewers can change the visual state of the poster (*e.g.* the appearance or position of the poster elements), from a negative to a positive panorama or the other way around. Thus, we also propose the adoption of similar techniques whenever it is intended to teach or encourage the viewers to change behaviours.

Ideally, the developed posters should be presented in controlled scenarios, on the street or in an exhibition room. However, due to restricted conditions of the pandemic we have passed through during the development of this dissertation, the posters were presented to the public through an online exhibition.

Lastly, user testing was conducted in the form of an online survey with the goal of assessing whether or not the proposed solutions (interactive moving posters) were more effective over existing poster formats, such as static and moving posters. Furthermore, the questionnaire was used to retrieve user feedback on how to further improve engagement and message transmission.

Due to the statistically low number of responses gathered, the questionnaire results may be interpreted cautiously. Also, the fact that some testers could not access the interactive version of the posters using their web browsers, may have led them to choose the animated and static versions of the posters. Nonetheless, for most posters, the gathered results revealed the preference of the users for the interactive posters to the detriment of the animated and static ones. This suggests that the adoption of interactive techniques may be a way to go in the future for creating more attractive and engaging communication design artefacts.

1.1 Framework

Since the advent of the personal computer and the resulting digital revolution, the world has been abruptly dominated by digital media. Nowadays, humans are constantly interacting and being exposed to digital technology, either directly by using a smartphone or indirectly by casually observing a digital MUPI or billboard on their way to their jobs. This way, the relation between humans and technology became an essential field of study. Consequently, the knowledge and methods of fields like Human-computer Interaction (HCI) and Human-Centered Computation (HCC) are increasingly included in the design creation process.

With the excessive amount of content published online, designers had to adopt different skills to combat that and make their content stand out. Designers are changing the paradigm of traditional graphic design artefacts to make them more appealing, and the poster was not an exception. We can revolutionise the traditional static poster and its creative process by grasping the computer's endless creative possibilities, mainly through coding. Having said that, we are increasingly observing animation being added to the digital poster to gather the attention of passerby and interactivity to keep that person engaged and make the message more effective and clear.

This dissertation, therefore, seeks to explore how fields of study such as Algorithmic Design, HCC and HCI will impact the relationship between digital media and humans, especially in the design of animated and interactive posters.

1.2 Motivation

After the Industrial Revolution, posters became a medium for mass communication for an industrialized society, quickly transforming the street's environment, filling every wall, light pole and corner with an overwhelming amount of these artefacts. Designers created new heavier letters and applied innovative printing colour techniques (Chromolithography) to make their communication artefacts stand out amongst a highly saturated streets environment filled with communication artefacts.

This problem of an environment saturated with information simultaneously fighting for the people's attention got accentuated after the Digital Revolution, not only with the emergence of street digital MUPIs and billboards to announce on; but also in this developing creative environment, the internet. This new creative canvas (internet) quickly became overly saturated. Nowadays, people are living in the era of knowledge. The recent technological advances (such as smartphones, computers, digital street billboards, etc.) allow us to live in a time when we can access so much information in real-time through our fingertips. This way, digital media became the mainstream source of information and advertisement. A vast amount of people depend on digital media (Online Newspapers, Online Articles, Social Media, etc.) to inform themselves; that is why it has become an essential part of

of almost every person's life ("The importance of Digital Media", 2021).

Often, designers try to explore and create innovative communication artefacts. Furthermore, since digital media are probably the most influential contemporary media for communication, digital technology and computer programming have been increasingly used to explore and exploit graphic design artefacts. By fully understanding and employing these tools, we may find solutions that are not possible or would be really difficult to achieve using off-the-shelf DTP software such as *Adobe InDesign*, *Adobe Photoshop* and *Adobe Illustrator*.

In this dissertation, we are motivated to study future possibilities that digital media approaches enable in GD, especially in the context of communicating a message. Also, we are interested in studying how the designer can include these approaches in the traditional medium of GD — the poster. The principal motivation in this dissertation is to create a set of posters while employing multidisciplinary knowledge from fields such as GD, HCC, HCI, and AD. How can these approaches, especially animation, algorithms and interactivity, applied to GD, influence the poster's effectiveness and appeal compared to the static poster.

1.3 Scope and Objectives

This dissertation focuses on the conceptualization and development of digital graphic design artefacts, more specifically, in media that resemble poster designs, where animation allows to convey the information in an interactive and customised way. This way, the scope of this dissertation includes the multidisciplinary research between the fields of GD, Algorithmic Design, HCC as well as HCI.

The main aim is, therefore, to create a set of interactive moving posters, that visually translate data gathered either in a direct way (i.e. reading and tracking the behaviour viewers and the state of its surroundings) and/or indirect way (i.e. accessing to context-aware data and data collections based on the state of its surroundings).

The posters are designed under the theme metamorphosis, exploring how the viewers and the environmental changes may affect the value of the message transmitted and, consequently, produce different behaviours in the viewers. Also, environmental problems have been defined as a sub-theme. This way, each poster reflects on a different environmental issue (Air Pollution, Biodiversity Loss, Deforestation, Global Warming, Noise Pollution, Waste and Water Pollution). The resulting designs are displayed as a whole in an online exhibition.

The work of this project was divided into three phases. In the first phase, we reviewed the history of Poster Design and how the field has adapted to new technological scenarios over the centuries, giving special focus to the recent innovative digital technologies and media (i.e. moving, generative and interactive posters). In the second phase, we iteratively designed, developed and evaluated a set of interactive posters until the desired message was transmitted as expected.

In the last phase, we designed and curated the exhibition as a website (developed from scratch), where the developed posters were made public.

This way, to successfully develop this dissertation, we have planned to fulfill the following objectives:

1. To collect and provide a brief historical-cultural background about GD, especially focused on the Poster Design history and how the current advances in digital technologies have impacted this media.

2. To define the main theme for the set of poster designs (exhibition theme) as well as the message that each poster will transmit.

3. To design each poster, define its characteristics and employed approaches as well as the source(s) of the data (e.g. direct and indirect).

4. To evaluate each poster individually in order to understand how successful is the transmission of its message and its impact on viewers.

5. To design, develop and curate a digital gallery (e.g. a website) to display the generated posters.

6. To evaluate the whole set of posters collectively to understand the impact of this media on viewers.

7. To provide and disseminate the results and make them publicly available.

1.4 Document Structure

This dissertation is divided into five chapters: (i) Introduction; (ii) State of Art; (iii) Work Plan and Methodology; (iv) Project; (v) Evaluation and, lastly, (v) Conclusion and Future Work.

In the first chapter, Introduction, we explain the theme and the field of research the dissertation focuses on, followed by the framework, motivation and objectives. In the second chapter, State of Art, we present the evolution of the poster throughout its history, from ancient times to the present, along with the review of relevant existing projects. In the third chapter, we present our work plan and methodology. In the fourth chapter, Project, we present some of the preliminary work developed in the first semester, explain the concept and the implementation process for each poster, and finalize referring to the online exhibition where the public could experience and interact with the final posters. In the fifth chapter, Evaluation, we present user feedback about the posters gathered through an online questionnaire. Lastly, the sixth chapter presents conclusions and future work.

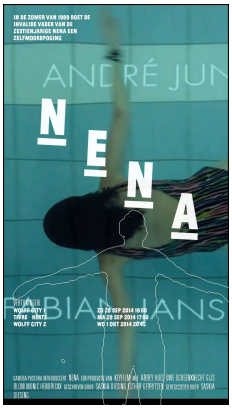
2. State of the Art

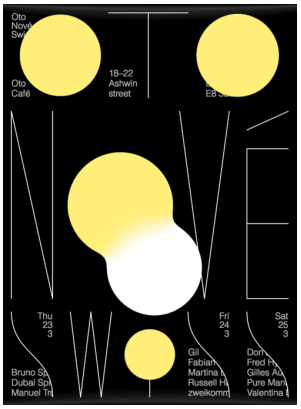
Posters are a popular medium for mass communication that can combine several visual elements (*e.g.* typography, illustrations, photo-realist image, *etc.*) to quickly and efficiently convey a message, or an idea, in an eye-catching and engaging way.

As a medium of communication, the poster has a long history and a wide range of social functions, from advertising a product/event to political propaganda. Even though poster designs are constantly evolving and changing along with the technological advances of the times, their primary purpose as a visual communication artefact remains fairly the same — attracting people's attention and transmitting a given message (Strizver, 2016).

Also, since their creation, poster styles have been constantly changing according to the *zeitgeist* of the epoch, aligned with the art movements, the social shifts, and, again, the technological advancements and improvements. This way, their visual characteristics are often indicators of cultural, economic, political, and social realities of the time in which they were created (Sontag, 1970; Strizver, 2016). The books from Meggs & Purvis (2009) and Guffey (2014) present a good overview of these changes.

In an overall analysis, it is noticeable that graphic designers always tried to grasp and explore the full potential of the available technologies to make the poster a more effective communication medium. Some examples of this are the invention of Chromolithography (a cheap coloured print technique) and massive wood-type typography during the Industrial Revolution, the exploration of DTP or even the use of computer programming since the emergence of the Digital Revolution (*circa* 1990s). These techniques enable the adaptation and improvement of posters to the socio-economic characteristics of the times. Nowadays, for instance, we are observing the exploration of techniques related to disciplines such as animation and interaction to make posters a more captivating and engaging artefact to the audience (e.g. Camera Postura (LUST, 2014), Oto Nové Swiss (Studio Feixen, 2017), BBC Reith Typeface (Brewer, 2018)).





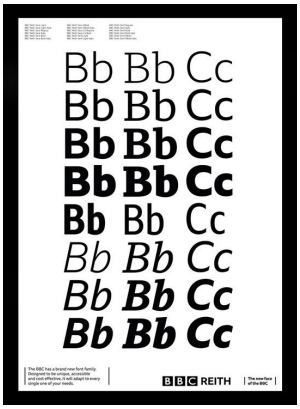


Figure 2.1 (**left image**).
Camera Postura poster.
Available at https://lust.nl/#projects-5939

Figure 2.2 (**middle image**).
Camera Postura poster.
Available at https://www.studiofeixen.ch/oto-nove-swiss/

Figure 2.3 (**right image**).
Animated poster for the BBC typeface.
Available at https://spin.co.uk/work/bbc-reith

During the following subsections, we present more detailed studies on the evolution of the poster over time, along with the analysis of relevant existing work that we considered to be related or to offer positive insights for conducting our project.

2.1 The Poster in the Pre-Industrial Revolution times

Already during ancient times, in Rome, precursors of the poster were found placed on the streets. At the time, their primary function was the proclamation of public notices, especially news about topics of general interest, *e.g.* events, prominent births and deaths, the cost of grain, political propaganda, *etc.* (Sontag, 1970; Meggs & Purvis, 2009).

Figure 2.4.
Acta Diurna stone (131 *b.c.*).
Available at https://www.messagetoeagle.com/acta-diurna-worlds-first-newspaper-appeared-in-131-b-c/

During Julius Caesar's governance (49 B.C. to 44 B.C.), long before the invention of typography and the worldwide invention of paper, the best solution for spreading information was the *Acta Diurna* (Figure 4), which means "daily acts" and consisted of the daily Roman official notices. These were carved on the materials available at the time, usually stone or metal and were presented in message boards situated in public places with large affluence of people, like the *Forum Romanum*. The *Acta Diurna* introduced and popularized the expression *publicare et propagare*, which means "to make public and propagate." (Sontag, 1970; ACM, 2019). These public notices were communication artefacts entirely composed of words, not only because of the lack of resources to use images and colour, but mainly because they were inserted into spaces that, at the time, were not filled with other communication artefacts. Thus, their goal was not to stand out among other notices but to inform the passers-by (Sontag, 1970; Wright, 2015; Blauvet, 2011).

In 1440, Johannes Gutenberg introduced to the western world the first printing machine ready to be used commercially — the Gutenberg Press (Figure 5) —, which only worked as seamlessly due to the fact that Gutenberg had invented his own printing ink. Until then, books were costly and rare because these were handmade and, consequently, time-consuming to produce. For instance, until 1424, there were only 122 manuscript books in the Cambridge University Library (Meggs & Purvis, 2009). The Gutenberg Press affected book production, enabling the effortless reproduction of books, helping, therefore, to expand literacy and knowledge around the world. This invention was kept as the preferred and mainstream printing mechanism during the next three centuries until the invention of Lithography, during the Industrial Revolution (Meggs & Purvis, 2009; Mayor & Oldenburg, 1971).

Figure 2.5.
Gutenberg printing Press (1440 *a.d.*).
Available at https://interestingengineering.com/the-invention-and-history-of-the-printing-press

2.2 The Industrial Revolution and the Modern Poster

An important momentum for the emancipation of the poster was the Industrial Revolution, which started in England between the 1760s and 1840s and promoted a radical social and economic change in the society of the time. For instance, until the invention of the Steam Engine (Figure 7) by James Watt (*c.* 1736 – *c.* 1819), human and animal forces were the main sources of energy for labour. This new steam energy fostered the transition from an agricultural society into an industrial society (Meggs & Purvis, 2009).

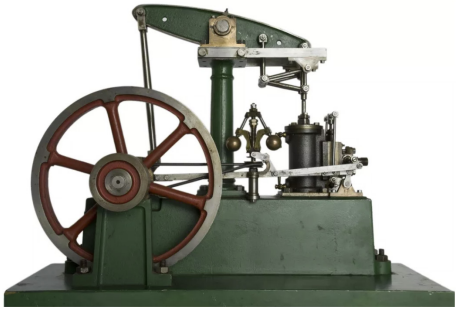


Figure 2.6.
Steam Engine.
Available at https://www.livescience.com/44186-who-invented-the-steam-engine.html

Among many technologies, printing was highly impacted by the advances of the Industrial Revolution. As referred in the previous section, before the 19th century, the dissemination of information was mainly made by books and public notices. These were both passive artefacts

in the sense that they needed the user's predisposition to read them. After the Industrial Revolution, people started to agglomerate in cities, which led to a higher demand, requiring the creation of mass production methods and, consequently, mass communication.

Lithography, considered one of the main responsibles for the birth of the modern poster, was created in 1796 by Aloys Senefelder and was one of the most significant technological advancements in the printing industry at that time. This technique was the first method of planographic printing (*i.e.* printing from a flat surface or plane) (Figure 2.7). Although lithographs could be produced cheaper and easier than previous printing techniques, colour printing was still expensive since the various colors had to be painted and applied by hand. That fact was changed with the Three Stone Lithographic Process, also called Chromolithography, an invention of Jules Chéret, from 1866. This new process consisted in adding colour to the original lithograph using three stones (Figure 2.8), one for each primary colour (red, yellow and blue). This allowed printing with any existing colour and it was the first time in history that colour printing was available at an accessible price. The Figure 2.9 is a good example of the colour range and vibrance of the Chromolithography (Meggs & Purvis, 2009; Mayor & Oldenburg, 1971).

Figure 2.7.
Lithography Press.
Available at https://www.prepressure.com/printing/museum

Figure 2.8.
Chromolithography Stone.
Available at https://www.prepressure.com/printing/museum

Figure 2.9.
Designs chromolithographed on tin food and tobacco packages
Available at https://havingalookathistoryofgraphicdesign.blogspot.com/2012/04/design-language-of-chromolithography.html

Due to the emergence of the aforementioned printing techniques, posters started to be massively multiplied and spread in the urban environment, leading these to become the primary source of communication of the epoch (Blauvet, 2011). This occurrence transformed the public place into a modernized environment, as the streets became sided by large and colourful posters, and the public is viewed as a spectator and consumer (Sontag, 1970; Meggs & Purvis, 2009).

> *"...the advent of the poster reflects the development of an industrialized economy whose goal is ever-increasing mass consumption..."* (Sontag, 1970).

This way, in an environment overwhelmed with communication artefacts, a poster design had to change its main purpose from just disseminating legible and explicit information, to give more importance to the visual appeal of its design, so it could stand out among other posters and, consequently, grab the attention of passers-by (Sontag, 1970).

In order to accomplish that, the designers needed to create "aggressive" and striking visual elements. This was accomplished by developing and adopting innovative typefaces, bigger and heavier in scale, to provoke a more significant impact on the audience and grab the viewer's attention, even at a distance. The new characters became much more than just a way of communicating, turning into abstract shapes capable of projecting a powerful impact through their high contrast and colossal dimensions. Robert Thorne created a font to combat this problem of oversaturation (Figure 2.10). (Meggs & Purvis, 2009; Guffey, 2014).

Figure 2.10.
Robert Thorne Type
Retrieved from (Meggs, 2009)

As far as we know, the modern posters were the result of various simultaneous and separate events. First, the necessity emerges from the need for mass communication artefacts. Then, its usage is stimulated by the lift of traditional strict censorship in some European countries and the adoption of the faster and more effective printing techniques, which enabled artists like Jules Cheret to design posters in a innovative way and to visually explore new subjects (for instance, the exploit of feminine figures, also called "Chérettes") (Guffey, 2015). The three images below are all examples of Chromolithographic poster (Figure 2.11, Figure 2.12, and Figure 2.13).

Figure 2.11 (left image).
"La Goulue au Moulin Ruge", Henri de Toulouse-Lautrec (1891)
Available at https://www.metmuseum.org/art/collection/search/333990

Figure 2.12 (middle image).
"Chiozza and Turchi", Adolf Hohenstein (1899)
Available at https://www.museunacional.cat/en/colleccio/chiozza-e-turchi/adolf-hohenstein/000592-c

Figure 2.13 (right image).
"Pantomimes Lumineuses", Jules Chéret (1896)
Available at https://www.yaneff.com/products/pantomimes-lumineuses

2.3 The Digital Revolution and the Post-Modern Poster

After the substantial advancements made during the Industrial Revolution, radically changing the posters paradigm, the next impactful transformation in posters design came with the advent of the personal computers — the Digital Revolution. At the end of the 20th century and since then, electronics and digital technologies have advanced at an extraordinary rate, revolutionizing almost every area of human activity and GD was not an exception (Meggs & Purvis, 2009; Armstrong, 2016). The computer has radically changed the tools, methods and processes of the GD creation, from a manual and physical environment, using ink and paper, to a digital environment, using the keyboard, mouse and pixels (Richardson, 2016). Computers existed for decades before the beginning of the Digital Revolution. The turning point was propelled in 1968 by Douglas Engelbart and his team (SRI's Augmentation Research Center) with The Mother of All Demos, demonstrating numerous technologies that we all now take for granted (Hintz, 2018).

These technological advancements brought by Douglas Engelbart and continued by his colleagues changed the paradigm of computation from something unusable by ordinary people to something user-friendly and simple enough to be used by anyone, which drastically changed the relationship between humans and computers (Smith, 1999).

This new paradigm brought a large number of new creative possibilities, and in the GD field, these were especially fostered by the invention of Desktop Publishing software (DTP). Contrary to what most people thought (that digital technologies would suppress graphic design), it ended up happening the reverse. Graphic Design was quickly adapted to this new creative momentum. Amongst the pioneers in adopting computers in the GD process and in the creation of innovative DG artefacts as a result of it are the designers Muriel Cooper, April Greiman, Rudy Vanderlans and Zuzana Licko (Meggs & Purvis, 2009).

2.4. Interactive Printed Posters

As mentioned in the previous sections, in GD there is a constant need for creating more attractive and engaging posters, and besides looking for new visual styles, designers have been also exploring new ways for leading people to discover posters more carefully and curiously. Interactivity is one of the approaches used to that purpose, as it enables designers to integrate the audience (users) in the definition or transformation of the posters's behaviour to transmit the message in a more alluring and effective manner (Morcos, 2021; Neves, 2021).

Since the Digital Revolution and the consequent emergence and democratisation of digital technologies, interactivity has become associated with digital mediums, such as computers. Nevertheless, its concept is a broader one, being defined as the mutual communication (giving and input, an output is returned) between two entities, typically, a human and any other object/artefact (Morcos, 2021). For instance, there has been work on interactive GD artefacts using, for example, traditional printed formats (Neves, 2016; Armstrong & Stojmirovic, 2011).

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An example of this is the interactive installation So Me Thing Kunsthal, made by Studio Spass for the exhibition Do it, at Kunsthal Rotterdam (2015). This project consisted of a wall installation made of a set of paper pages containing different patterns that were grouped in stacks of 50 and disposed on the wall in a 17x9 grid, allowing the reading of the sentence "So Me Thing". The installation invited the audience to playfully discover the hidden patterns by tearing sheets of paper for unlocking different patterns and thus creating new typographical compositions (Korvinus & Mens, 2015).

Another example of an interactive printed artefact is the Zeit für die Bombe Book by Agnès Wartner (2007). The title of this book comes from a hypertext story written in 1997 by Susanne Berkenheger and which should be read on the Internet (using a browser). Berkenheger used one of the great potentials of the web, hypertext, to create an interactive multilinear story. The reader could click on numerous hypertext to be transported to different text passages, thus determining the narrative process himself (Wartner, 2007). The project of Wartner, presented a cross-media approach to transform Berkenheger's interactive narrative from the web onto paper. To accomplish that, the hypertext was represented using large letters accompanied with circular cuts in the page, letting the reader intuitively access the respective pages with a single action (behaving similarly to digital hypertext). Thus, using simple interactions such as putting a finger in the page-cuts, the reader

could flip different pages to determine different courses for the story (Wartner, 2007).

Furthermore, there are also examples of interactive features in printed posters, such as the set of posters of Harriet the Spy, by Tree Abraham (2014). This work consisted of three hand-illustrated posters advertising the book and film Harriet the Spy (Tree Abraham, 2014). Each poster actually consisted of two different images that could be shifted by pulling and pushing a mechanical pull-tab, also made of paper (Tree Abraham, 2014).

The analysis of the aforementioned work, helped us understand that the inclusion of interactive features in design artefacts has been seeked in different ways, as it seems to have a positive impact in attracting the interest of the audience to the designs and encouraging our research.

2.5 Digital Algorithmic Posters

Since the democratisation of the DTP tools, designers have tried to explore the full power of the computer to create innovative designs. Nevertheless, the off-the-shelf software was revealed to offer a somewhat limited amount of creative solutions. This has led practitioners to conclude that the best way for fully using the impressive processing power of the contemporary computer was through coding. By fully exploring algorithms, it is possible to use the computer as more than a canvas to display content, but a novel medium with its own unique set of properties, characteristics and attributes that offer the possibility to develop new and endless creative solutions (Richardson, 2016).

An Algorithm can be defined as a finite series of well-defined instructions that, when implemented and followed step by step, can be used to solve a specific set of computable problems/tasks. Thus, by the medium of Algorithmic Design, it is possible to generate infinite sets of solutions (or variations of similar solutions) for a singular problem, by setting a list of coding constraints and parameters. Also, code can be useful to ease the automation of complex shapes, forms and other elements that would be extremely difficult to accomplish manually (Pristia, 2019). In that sense, algorithms can also aid the generation (integral or partial) of new solutions for poster designs (Erickson, 2019).

One of the pioneer designers using the potential of coding in the GD scenario was John Maeda, a graphic designer and computer scientist who has been highly influential in the design and technology area, and whose interests reside especially in the merge and collaboration of these two areas (design and coding) to create something bigger than its parts (Richardson, 2016). His work has redefined the use of code in GD, as he has shown the design community that coding could actually be used to successfully create innovative designs, and thus laying the foundations for a design area that is now referred to as Creative Coding (Richardson, 2016).

For instance, one of his most recognised projects is the creation of the programming language *Design by Numbers* (DNB), in 1999. This initiative had the goal to teach and introduce code to the visual artist's community through a free and custom software system/tool he designed. Although this programming language is no longer available, it has influenced the development of the popular programming library *Processing*, created by Maedas's former students, Ben Fry and Casey Reas, for easing the coding process for designers and artists (Richarson, 2016). Nowadays, thanks to projects such as *Processing*, graphic designers do not need an extensive experience in computer science to explore the opportunities of coding, so more and more designers are currently learning and including code in their design processes.

An example of a project exploring the generation of visuals through the use of code is the graphic identity of *Poetry on Road*, an international literature festival held annually in Bremen, Germany (from 2002 to 2013). During these eleven years, these visuals were designed by Boris Müller, sometimes in collaboration with studio *NAND*.

Each year, the festival organisation used to choose a new theme and a new promotional poster was then created using a generative design approach. While the theme itself was changing yearly, the principal idea behind the visual identity stayed the same: transforming text into computer-generated images (Müller, 2002). In the first edition (2002), the concept was to use poems sent by participants and to transform each individual letter of the poems into a shape. Each letter had its own colour and size, and the shape angle represented the language the poem was written in. This resulted in a colourful and dynamic set of shapes that gave the perception of movement when seen from different angles (Müller, 2002). In the last edition of Poetry on Road, the poems were transformed into heat maps. That was accomplished by iterating each word and then trying to find a geographic location with that same name (or using that name as an acronym to find a match). Then the respective coordinates (latitude and longitude) were used to represent the given word in the canvas. For example, for the German word und, the first result would be the University of North Dakota, with the coordinates 47° 56′ N, 92° 2′ W. After searching a physical location for each word in a poem, the name of the respective location would be saved in a database and then used to generate a heat map, using the *Dymaxion* projection by Buckminster Fuller (Müller, 2002). tThus, by just changing the given poem and colours of the heat map, an infinite number of versions of that poster could be created.

As mentioned before, to explore the full potential of the computer as a medium for visual exploration, stepping away from the DTP may be necessary, exploring the possibilities of computer programming instead. However, many times, using a mixture of tools, such as DTP software and coding, may be an advantageous approach. In that sense, some DTP software started to offer the possibility to code directly in the DTP environment (scripting). For instance, designers can already do that using *Adobe's software* (probably the most used set of software for doing graphic design).

A good example of this approach is the generative poster system *Diploma*, created in 2007 by Benedit Groß and Julia Laub. In this work, the designers explored and created multiple scripts for Adobe InDesign. The result was a set of generative posters, each with a different grid layout displaying the effects created by the different scripts implemented (Groß, 2007). More recently, in a similar sense, Diogo Ferreira developed Scripted Pages (2019), a system for allowing the generation of layout designs based on a set of rules for macro and micro typography (Ferreira, 2019).

The project The Poster Wall for the 21st Century, designed and developed by LUST in 2008, explores the generation of personalized messages and automated design through an interactive installation presented in a projected digital canvas of ever-changing posters. This is a good example of the usage of digital technologies and creative practice to automate the generation of graphic design artefacts. In this case, an interactive installation of posters. This system was driven by an algorithm that continually and autonomously generated up to six hundred new posters by day, using content created and sent by the viewers (LUST, 2011; Peeters, 2017). The project aimed to explore the concept of mass communication, so the digital wall was meant to resemble the ″visually and verbally saturated environments″ (Guffey, 2015, p. 8) of the Industrial Revolution, by overlapping an overwhelming amount of posters (LUST, 2011). The modern poster, born ″with the widespread use of chromolithography in the late nineteenth century″ (Guffey, 2015, p. 8) strove to capture and immobilize the viewers′ attention, mainly through its striking visual elements. This project uses that same concept (catching viewers′ attention) using the interaction, not with the elements of each poster, but with the whole installation. In other words, each poster composition could change its position on the wall by following the viewers (LUST, 2011). We consider this particular project noteworthy, as it resembles many of our thesis goals by (i) exploring a well-established visual communication artefact (the poster), (ii) using digital technologies, (iii) merging code and design to create interactive moving artefacts, and (iv) making the viewer′s experience more immersive and captivating.

Between 2008 and 2010, LAFKON created several different posters for the *F/LOSS-orientated* festivals, conferences and conventions LAFKON is a graphic design laboratory occupied by Benjamin Stephan and Christoph Haag. These designers used custom F/LOSS software setups and *Bash Script* to generate parametric posters, well optimised for cheap reproduction. An interesting feature of this project is that after being generated, the posters would be automatically available for download and self-print (LAFKON, 2011).

In 2010, Paul Cleveland developed a style-based generative layout approach which could be applied to either magazines or web design. This approach consisted in generatively creating layout by using a grid as a base to place elements. To put this in practice, a program was created using *Processing*. By clicking and sliding, the system enabled the user to change the value of several parameters, such as the number of objects,

vertical/horizontal symmetry, balance, among others. Also, this project allowed the quick generation of an infinite number of versions for a single page, using the same text and images, by simply changing the relation between these, their size, position, and colour (Cleveland, 2010).

Another example of the unlimited creative possibilities of using code to generate Graphic Design artefacts is the set of posters (13 in total) done by Sidi Vanetti for *The Puddle*, an electronic music event. For easing the creation of different design variations for the graphic identity this festival, the author has created an interface in *Processing*. The latest was composed of checkboxes and sliders, each one having a different set of parameters that could be changed and explored to create different visual results (Vanetti, 2013).

As aforementioned, the project of Paul Cleveland (2013) explored the generation of a single page document. Taking it further, in 2017, Yunke Zhang developed a system to automatically generate banners for multi-size and multi-style documents (Zhang, 2017). Although the banners design process included several different tasks, such as picking typefaces, colours, images, *etc.*, the project was specifically focused on the layout aspect. To address that problem, three approaches were explored: learning the style of fixed-size layout, style interpolation among different sizes and (multi-size) style transfer using minimal-style reference banners (Zhang, 2017).

One of the designers that has been influential in the exploration of computers for generating poster designs is Tim Rodenbröker, an enthusiastic supporter of creative coding and computational thinking in the realms of Art, Design and Digital Media. Probably, his most renowned project was *Programming Posters* (2018) where, in a workshop environment, he and his students created a set of animated and interactive posters through the use of techniques such as the *Processing's* "copy" function, that enables to deconstruct words and characters (Rodenbröker, 2018). To ensure all the created posters became visually harmonious, Rodenbröker developed a methodology called *The Magic Triangle*. Thus, to create a programmed poster, he and his students should follow three requirements defined. The first was to use two colours only (white and blue) and one single typeface, ensuring this way that the focus of the design process would be the exploration of the creative possibilities of coding and not ornaments. The second requirement was to use *Processing* and the third one was simply to explore and create a poster (Rodenbröker, 2018). Following this methodology, even people with the least experience coding, like Rodenbröker's students, still would be able to create fascinating poster designs that otherwise would be hard to accomplish or even undoable using standard DTP software.

The Environmental Adaptive Poster Composer is a system developed in 2017, by Rebelo *et al.* This project presents an interactive installation that creates posters designs using a generative design process. The posters were generated using a system capable of translating data retrieved from the physical surroundings near the installation (which

highly inspired one of the functionalities of our work). The system tried to generate posters that seamlessly fitted into its placed environment. The implemented system used Computer Vision techniques to define which items to place in the poster as well as their lifespan. For example, the number of people near the installation or even the distance between these and the installation could modify the lifespan of certain elements. Furthermore, the system was able to examine whether or not the current poster design (output) was most suitable for that specific environment (Rebelo *et al.*, 2018).

Another work of Rebelo *et al.* that relates to our project was the *Evolutionary Poster Composer*, which was able to automatically develop typographic poster designs, exploring evolutionary computation approaches. In this work, the authors explored several strategies to evaluate the generated outputs: (i) a multi-criteria hardwired fitness function strategy (Rebelo *et al.*, 2017; Rebelo et al., 2020); (ii) a multi-objective optimisation approach strategy (Rebelo *et al.*, 2021) as well as (iii) hybrid strategies (Rebelo *et al.*, 2020).

2.5.1 Moving Posters

Nowadays, digital technologies and their continuous evolution shape how one interacts and consumes information, making digital screens one of the favoured mediums for publicity and communication. The amount of digital and animated content we contact every day made designers desirous for revitalising the traditional GD artefacts, for example, by including animation, computer-generated visuals and interactivity in their creations. Thus, posters are no exception. In the last few years, we have been experiencing the introduction and development of what we refer to as Moving Posters. This simple and effective approach allows designers to create artefacts that captivate the viewer's attention, since viewers have developed an unconscious habit of ignoring the traditional static printed posters to the detriment of animated artefacts (Slaterry, 2019).

The *Moving Poster Repository* (themovingposter.com) is an online moving poster inventory curated and designed by Josh Schaub. Besides presenting a good overview of this kind of designs, this project helped define and expand the notion of this new up-and-coming type of poster design. It shows the wide range of possibilities one can achieve with this medium, as well as its limitations. The objective of this initiative was to answer a few pertinent questions such as ″What are the techniques and methods of narration?″, ″Where does the poster end and where does a film begin?″ and, the ultimate question, ″What a poster actually is and how this medium will continue to develop in the future?″ (Schaub, n. d.). Schuabl defines the moving poster as a medium positioned between the traditional static poster and the film (animated). It uses the animation from the film discipline while keeping the main core objective of the static poster — attracting and communicating (Schaub, n. d.). Also, this repository lets the user filter for different types of moving poster designs, demonstrating the vast possibilities of this communication medium. The filters list goes from simpler

examples, such as ″Static″ to more complex ones like ″Many smaller divided movements″ (Schaub, n. d.). Currently, the repository presents fifty-three posters and the curator is looking to keep expanding it.

Nowadays, good examples of moving posters are present both in the digital and physical world. The animated poster campaign for the *BBC Reith Typeface*, made in 2018 by the graphic design studio Spin, is a good example of the potential of this medium. In this project, using a small group of posters with simple and clean black and white animations, the designers were able to better demonstrate how adaptable the *BBC Reith Typeface* was. For example, by unveiling its attributes and quirks in each poster, *e.g.* displaying the typeface family with its different weights and all the available language sets (Brewer, 2018).

In the same year, the studio Feixen created an eye-catchy simplistic poster for the *Nike Air Max Day*, a worldwide event to honour and celebrate the creation of the Nike Air Max series, that occured on 26th of March of the same year in several different cities (Studio Feixen, 2018). In the early stages of development of this work, the studio Feixen had different concepts on the table. However, the idea that stood out was a typographic system that reacts to gravity. The poster becomes a metaphor for the atmosphere (air); the letters enclosed inside are objects that react and collide with each other. But while these try to move vertically, sudanlly, gravity switches on and pushes them down (Studio Feixen, 2018). A static poster was also created, in which the letters were usually condensed to one of the sides of the poster to give the perception of a 2D gravitational pull. While this static version was easy to comprehend (understand the concept of zero gravity inflicted on the letters) and thus it functioned well, the animated version seemed to work even better, being a more exciting and eye-catching communication artefact (Studio Feixen, 2018).

2.5.2 Interactive Moving Posters

Interactive Design is a user-oriented field of study that focuses on the relation between humans and computational designs. As already mentioned, after the advent of personal computers, designers started using code to explore the potential of this medium, which led not only to generative posters (mentioned in the previous Sections) but also interactive design artefacts. The goal of this approach focuses on transforming any type of input data (*e.g.* sound, motion, other sensor′s data, the position of a given controller, *etc.*) into a visual/sound animated output, in real time (Richardson, 2016).

The previously presented Moving Posters are often designed based on a set of temporal states, displayed to the user in a sequential way. But although these present the information employing storytelling techniques, they can only communicate the same information over and over again, not being influenced by any input external (Benyon, 2016). According to the *Screen Design Principles* (see Macklin, 2008) point of view, moving posters are still not an optimal solution, as concepts such as ergonomics/human factors, HCI and Interaction Design

may enable the development of techniques that allow the emergence of more engaging approaches to the viewer. Thus, in the coming periods, Moving Posters may become mainstream and thus should evolve to start responding to their environment using information gathered by input devices (such as cameras, RFID tags, or audio devices), turning this way into Interactive Moving Posters (Benyon, 2016). Thereby, digital technologies must be used to enable dialogues between design artefacts and the viewers, and must promote the seamless participation of the user and the serendipity of data derived from a process-oriented GD (Armstrong & Stojmirovic, 2011).

In sum, Interactive Moving Posters must allow the user to reshape the way that the information is presented. This rendering can be either direct, via user interaction, or indirect, via contextual ambient/user data. Also, Interactive Moving Posters may allow the incorporation of data through computational techniques, such as Computer Vision (CV) or Pattern Recognition. And although this is a relatively new and unexplored area, some applications already exist.

Between 1994 and 1999, John Maeda developed Reactive Books, which consisted in a series of five digital books that explore and develop the concept of Reactive Graphics. Each of these books explored a different input type. The first book was entitled The Reactive Square (1994) and was inspired by Kazimir Malevich's painting, Black Square (1915). The book contained ten squares that reacted to the input of a microphone. After that, came Flying Letters (1995), which used the mouse input to manipulate typographic "marionettes". Maeda then created 12 o'clocks (1996), which displayed time in various digital formats. Then, he realised Tap, Type, Write (1998), which the author defined as an homage to the typewriter. The last part of this project was Mirror Mirror (1999), which used video input to create interaction (Richardson, 2016; Maeda, 2005). This was a pioneer project in the area of interactive GD, that opened the way for future designers and that still is studied in current days (Richardson, 2016). Nevertheless, while the inputs used by John Maeda were intrinsic to the computer (keyboard, mouse and microphone), nowadays it is credible to use almost anything as an input, from external sensors to more complex inputs like pose and movement detection.

Regarding Interactive Movie Posters, one of the earliest examples is the installation Camera Postura (Figure CAMERA_POSTURA), presented by LUST and LUST lab during the Netherlands Film Festival in 2014. This project is similar to ours since both use body tracking (skeleton) as interactivity (LUST, 2014). The installation captured the viewer's gestures and tried to match these to a given movie scene. For example, a scene where an actor performed a similar pose or had a similar facial expression. To accomplish that, it was first necessary to gather several movie clips that included actors' poses, movements or expressions. Then, using two Microsoft Kinect II and computer vision techniques, such as pose detection and facial expression detection, the system would try to find a match among gathered footage. Once a movie matches the user's pose, a new poster would be created using

the following elements: the movie title, reviews, custom labels, nominations and awards, credit block and tweets (LUST, 2014; OPENRNDR, 2018).

A simple and effective example of using interactivity to transmit a message is the work *The Coughing Billboard*, a stop-smoking advertisement made by Akestam Holst Agency for the Apotek Hjärtat Pharmacy in 2017. This interactive billboard was displayed on a digital screen and used a smoke detection sensor. Every time a person was smoking near the poster, the person ″inside″ the poster started coughing, demonstrating that smoking not only affects the smoker, but also people around it. Thus, the billboard tried to motivate a change of behaviour — stop smoking. Furthermore, after the coughing stops, several medications to quit smoking appear, offering a solution to help adopting such new behaviors. In the end, the poster went to its original state and the process started over again. Thus, this is a good example of taking advantage of simple interactivity (only using a sensor for playing video) to enrich the transmission of a message.

In a similar way, the subway billboard campaign also developed by Åkestam Holst to the Swedish pharmacy chain Apotek, in Stockholm, presents a system that can gather information from the environment without a direct user′s interaction (Xie, 2014; Åkestam Holst, n. d.). This interactive billboard uses data recorded by ultrasonic sensors to make the hair of a woman model to be tousled by the 'wind' of the moving trains.

Another interactive street poster, a little more complex than the previously mentioned, was created by the Isobar Agency for *The Budapest Festival Orchestra*, in 2016 (Figure ISOBAR). To interact with the poster, the user needed to first connect their smartphone to the poster. Then, the poster would use the movement of the smartphone to conduct the poster's Orchestra tempo (so it would play slow, medium or fast), in real-time. While music heritage is a big part of Hungarian culture, fewer and fewer young people are attending concerts, so this poster had the goal of captivating the passersby, making them interact with the poster and creating a new excitement about music and such concerts (Isobar, 2016).

Studio Feixen also explored the use of interactive elements in their poster designs. In 2017, they created an interactive poster for the *Oto Nové Swiss*, a contemporary music and sound festival. This is an example of how one can create exciting and appealing communication artefacts by using a very simple computer input, in this case, the mouse. The created poster displays the festival name (*Oto Nové Swiss*) and places a coloured circle in the three ′O′s of the title and another in the ′i′ dot. Then, through mouse movement, the user can interact with these elements. The text reacts to the mouse position in a responsive manner, and the circles behave like metaballs when in contact with this same input. Since it was developed for a music festival, each mouse movement also returned a sound, so the user could also play its own music by interacting with the poster (Studio Feixen, 2017).

In 2018, Lopes et al., developed the visual identity for *Olhos Music Fest*, a music festival in Portugal. The concept behind this project was to explore the festival's name, Olhos, which stands for "eyes" in English. One of the parts of this visual identity was an interactive poster which used a webcam and Processing's OpenCV library to detect the viewer's eyes, taking a picture of these and chaining them to create dancing artefacts (like rotating accordions) that reacted to sound. In our project, we ended up adopting a similar approach for detecting different parts of the viewer's bodies (Lopes & Martins & Machado, 2018).

In 2017, Rebelo *et al.* presented an approach that explores the use of Computer Vision Techniques and Context-Aware data to create an interactive moving poster. The poster gathers information from its surrounding environment in two ways: (1) directly, via motion tracking and (2) indirectly, using contextual data, in this case, local weather data (Rebelo et al., 2017). The poster is composed of different elements: (1) rectangles, (2) circles, and (3) letters, each element with distinct behaviour. The retrieved value of local temperature (indirect interaction) affects the colour of the elements; that is, the warmer the temperature, the warmer the colours displayed, and vice versa. Then, it uses Computer Vision and face detection algorithm (direct interaction) to track the user face position and uses that data to animate the poster. The closer the user's face is to one of the edges of the camera, the bigger the rotation applied to these elements (Rebelo et al., 2017).

Despite not being a poster, we also refer to the project Plastic Air (2021), designed and developed by *Pentagram*. This project shares some characteristics with ours, from the concept of tackling an environmental problem (the microplastics), to the way animation and interaction was used to transmit the message more effectively. In other words, the project is a data visualisation artefact that uses the potential of animation and interaction to bring awareness to the impact of airborne microplastics, which despite being invisible to the naked eye and consequently unnoticed, do surround us from the air we breathe to the food we eat.

Plastic Air lets users explore the project through simple mouse clicks, making it an immersive and engaging experience. The canvas represents the atmosphere. Then, the particles flying in and out of it are representative of microplastics. To illustrate this increasingly invisible problem, the authors have decided to attribute a different shape/line to different component groups. For example, the fibre is represented by a line and the granules by oval shapes. For interacting, the user can select the particles moving around (mouse hover), which results in the display of additional information. For example, chemical composition (*e.g.* Polystyrene), the item it might have been originated from (*e.g.* Tupperware), its size (23µm) and the distance that it may have travelled through the atmosphere (*e.g.* 160km). Also, The user can insert an everyday object into the canvas which will instantly deconstruct into confetti-like particles from its own material, and it can also adjust factors like location (urban and rural) and weather conditions to affect dispersal patterns and change the type of particles launched (Pentagram, 2021).

Compared to our project, one of the most similar existing projects regarding direct inputs may be the interactive poster for the dance event *April Dances in Coimbra* (Portugal), by Roça & Amaral (2021). To create the promotional poster for this event, the authors took advantage of a webcam and the libraries ML5.js and P5.js to implement a pose detection algorithm (poseNet), which was used to detect the skeleton of the people standing in front of the camera. Then, whenever a person's pose was detected, music would start to play and the person's movements would be mirrored by colored lines that illustrated the poster, bringing the poster to life thus highlighting the issue of the event (dancing/body movement).

As a conclusion, it is noticeable that designers have already noticed the advantages of adding dynamism and interactivity to design artefacts and, this way, achieving more engaging solutions. Regarding Interactive posters specifically, there might yet exist some difficulties related to the materialization of these, as their technical complexity makes it difficult to spread them on the streets, *e.g.* as mupis. Typically, so far, these are implemented on the web or as single installations created on demand. Nevertheless, that can be also seen as an advantage, once this fact makes these posters less mainstream and thus these tend to better generate people's interest.

Having in consideration the engaging value of these artifacts, and the relatively small exploration of the field, we believe that our work can be positioned as a relevant contribution, as it studies more in depth the use of on innovative ways of interacting with digital posters, such and the mixture of direct (*e.g.* pose detection and sound) and indirect inputs (*e.g.* local temperature or air quality) to change the information on the posters in real time and use this to promote change behavior.

3. Methodology and Work Plan

3.1 Work Plan

In order to complete this dissertation successfully, a list of tasks was established and fulfilled. The Work Plan helps to identify those tasks and predict their duration. Thus, the list can be divided into five parts. (i) research; (ii) experimentation (Exploration); (iii) project development (Generation); (iv) evaluation and analyse of the obtained results (Evaluation); and writing the dissertation (Communication);

I. Research
The first phase of the dissertation consisted in researching and collecting information about the poster history and the impact of digital technologies in this artefact.

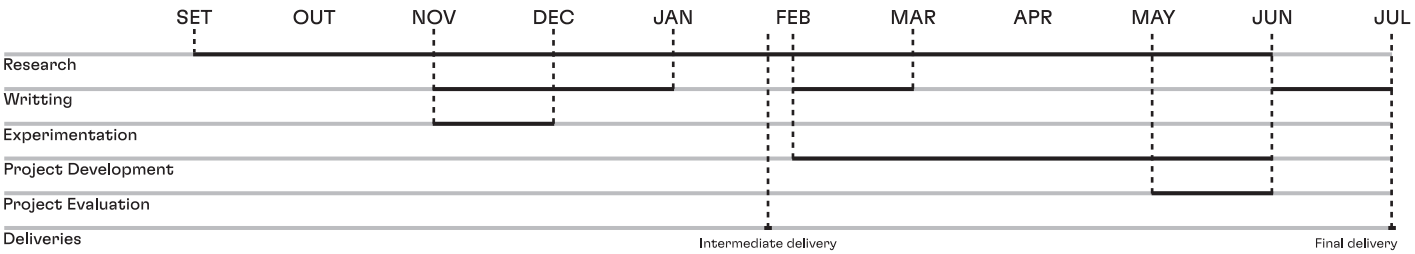
II. Experimentation
This phase is the predecessor to the project development and consisted in the exploration of different technologies and, simultaneously, creating several concepts for each poster utilising a series of mockups.

III. Project Development
The project development consisted of the conceptualisation and implementation of the set of posters. This stage also included the dissemination of the posters in the form of an online exhibition.

IV. Project Evaluation
Evaluation consisted in understanding if the posters worked technically well and if their mensagens were clear and understandable. This phase was also used to find any flaws and receive feedback to improve upon these artefacts. Lastly, we aimed to understand whether or not this new medium (moving poster) was more effective than existing static and animated posters.

V. Writing the dissertation
The writing of this dissertation can be divided into three phases: (i) intermediate writing; (ii) refinement and improvement of the State-of-the-Art; and (iii) completion of the writing of the dissertation.

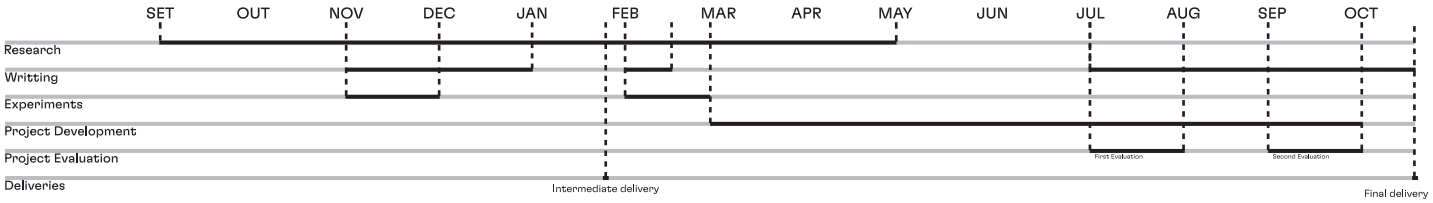
Gantt Diagram
Initial diagram showed in the Work Plan



3.2 Changes in the Work Plan

Compared to the work plan presented in the intermediate delivery, some changes have been made (also because the delivery of the project was extended from July to October 2021). The most significant alteration occurred in the project development phase. While our initial optimist guess was that it would take four months to create, refine and tweak all the posters as well as to create the online exhibition (website), this task took sensibly seven months instead.

Actual Gantt Diagram of the dissertation



3.3 Methodology

Given that the objective of our practical project was to create a set of posters focused on the interaction with the user, we considered it would be advantageous to use an agile methodology that could enable us to iteratively evaluate the developed poster designs (individually and as while) with real users and including obtained feedback in the development process, by using it to improve the tested posters.
The methodological model used was, therefore, the Four Stage Design Process (Cross, 2000). This model is divided into 4 stages: (i) Exploration; (ii) Generation; (iii) Evaluation; and (iv) Communication. Each stage is based on an essential set of activities that, usually, a designer performs during his work process (Dubberly, 2008).

In the first stage, Exploration, the designer must dedicate to completely grasp the problem faced and start sketching and exploring some possibilities to resolve it. For example, this may involve defining the requirements, considering what would be the most helpful tools to develop the project and sketching preliminary mockups. Following up, comes the Generation stage, where prototypes must start to be developed. The development of each prototype (or set of prototypes) is then followed by the Evaluation stage, where tests are done to find errors and flaws. This may include technical and user testing. After that, one must loop between the Generation and the Evaluation stages until the desired results are achieved. In the last stage, Communication, one may disseminate the results. In detail, this methodology was applied to the development of the dissertation as follows:

To complete the first stage, the exploration, we started by defining the list of environmental problems to tackle. After completing the list, we formulated several ideas for each environmental issue, representing these using a sequence of mockup designs that demonstrated how the animation and interaction with the user would be.

After having several mockups and concepts, we debated which should be used and implemented for each poster. The only environmental problem which had two distinct variants was Noise Pollution, and that was because both concepts were reasonably straightforward and quick to implement; in the end, we chose one of those to be displayed.

The following two stages, generation and evaluation, occurred simultaneously, implementing each poster step by step while discussing in between these steps the problems found or if work done till then was well executed.

We expected to involve users, preferably in a physical environment, in the evaluation process. Due to the imposed COVID-19 restrictions, we adapted the evaluation stage. This way, we evaluated the poster through the creation of two distinct online surveys. The first created during mid of August and the last one in the mid of September. We used both of these surveys to improve upon our posters. But in the second survey, we also wanted to understand if the interactive version was in any way superior to the static and animated.

After processing the results received, we went to the final stage of the methodology, Communication. In this stage, we displayed the poster's final version on the online exhibition. To conclude, we finish writing to deliver the dissertation.

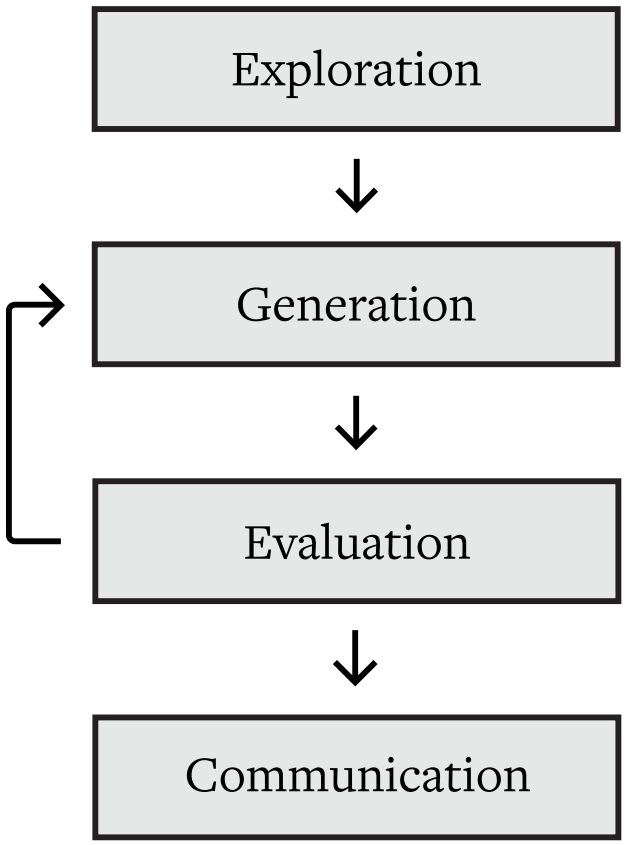


Figure 3.3.1.
Visual representation of the adopted methodology

4. Project

In the context of this dissertation, we will develop a set of interactive moving posters. The design of these posters will explore Metamorphosis as a main conceptual subject. This way, we will explore this concept as the main theme for the poster in a figurative and metaphorical way. The posters, therefore, will address the current metamorphosis of our planet due to climatic changes, *i.e.* the posters designs will explore different themes, such as Air Pollution, Biodiversity Loss, Deforestation, Global Warming, Noise Pollution, Waste and Water Pollution to communicate about them to the viewers.

We hope that the developed artefacts will bring awareness and attention to these issues. Each poster will reflect a distinct theme. The poster designs will heavily focus on the interaction with the viewer and the consequent effect of this interaction on the artefact, ensuring the way that the data is gathered and the consequent animation on the poster is related to the theme of each poster. This way, we believe that it will transmit most effectively the message, while simultaneously providing a rich and engaging experience to the viewer. Each poster will present two different types of reactions based on the state of their surroundings: (i) positive and (ii) negative; As the name implies, some inputs will promote a positive reaction of the poster (*i.e.* the transformation of the poster is positive to the viewers). On the other hand, some inputs will promote an opposite reaction (*i.e.* a negative reaction).

The developed poster will be composed of different visual elements. The behaviour of these visual elements will be defined by the behaviour of its viewers and/or the state of the environment that surrounds it (both digital and physical). Each poster is a group of endless design variations of its visual elements, i.e. each variation represents a unique moment in time and space. We believe that by understanding its context, the posters will convey their message as efficiently as possible, encouraging the viewer to change/maintain their behaviour. The set of posters is displayed in an online exhibition (student.dei.uc.pt/~rgoncalves/Website/), where the viewer will be able to observe and interact with them individually and collectively. The next subsections will compressively describe our preliminary work as well as the design and development processes behind each one of the final posters in the exhibition.

4.1 Preliminary Work

We developed some preliminary work to study how the poster's design visually looks and interacts with its viewers. This way, we created a prototype version of a poster directed at the Air Pollution issue, demonstrating multiple poster's states depending on the received inputs. This prototype is partly implemented utilising the p5.js JavaScript library (p5js.org).

The design of this poster can be divided into two layers, taking into account the second layer ended up not being implemented because we chose another concept. The first layer displays a list of six cities, including five cities worldwide (*e.g.* Warsaw, Milan, Mumbai, Dhaka

and Lahore), and the sixth city is where the user is accessing/viewing the poster. Each city representation is by its name and current Air Quality Index (AQI). The lower the AQI value, the cleaner is considered the city's air. This part of the prototype is generated through the use of an indirect input (retrieved from IQAir — "https://www.iqair.com/air-pollution-data-api"). This data defines the weight axis (thickness) of the variable font used (Work Sans from Google Fonts).

The second layer of the poster is an animated particle system. These particles represent the air pollution and the consequent fog caused by it. These particles would generate from the bottom of the poster, and their quantities are related to the amount of pollution (AQI) of the six cities combined. For the direct interaction, we would use Computer Vision to retrieve the movements captured from a camera. Our idea was to let the user try to clean the particles present, similar to what we implemented later on in the water pollution poster. This way, viewers' behaviour directly influences the poster legibility, i.e. to read the list of cities in the background (the poster's message), the viewers should perform a positive behaviour.

Figure 4.1.1.
Air Pollution Prototype (1/3)

Figure 4.1.2
Air Pollution Prototype (2/3)

Figure 4.1.3.
Air Pollution Prototype (3/3)

The development of this preliminary work helped us establish the creation/development process of this project. We divided each poster into two parts. The first one is to demonstrate the intended problem while retrieving relevant data; the second part of the poster focuses on the interaction with the user and how it can improve the transmission of the message. For example, in the final Air Pollution poster, we started by displaying the problem by retrieving the user's location Air Quality Index. As for the interaction, we used a Face Detection algorithm to launch smog (smoke + fog) particles into the poster.

4.2 Posters

In this subsection, we compressively describe the development and design of the posters as well as present the website designed to display the developed posters. As aforementioned, each poster tackles a different environmental issue. For this reason, each one has its own set of characteristics and interactions intending to transmit the message more effectively and engagingly.

Despite each poster being a separate artefact that communicates by itself, all the developed posters share some similarities and are developed exploring the same design methodology, i.e. each poster visually translates data gathered both directly and/or indirectly, using Computer Vision and Context-Aware data. Nevertheless, in order to enable the viewers to perceive all of them as one collection and to accomplish some visual cohesion between them, we decided to define two features visually shared by all the posters to ensure the viewer understands they are all from the same project, even when seen/ interacted with separately. The features are the following: (i) to place a message related to the subject of the poster in the centre of the canvas with the same typeface (GT Flexa by Grilli Type) in all of them; and (ii) to place a subtitle, i.e. a small description (Figure 4.2.1) and a logotype designed for the exhibition, at the bottom of the posters.

Figure 4.2.1.
Subtitle section on the Biodiversity Loss poster

Also, we design each poster, ensuring that they are as responsive and parametric as possible. In the presented designs, we used 95% of the window's height to display the poster height and calculate the width based on the 16:9 aspect ratio. This way, we ensure that these experiments, most designed to be visualised online, adapts its size to the viewer's screen, regardless of its dimensions and proportions. As far as we know, the only problem with this implementation is that the sides of the poster can be hidden in really tall smartphone screens. The Figure 4.2.2 shows an example of using the poster in a smartphone with the size of 1080 by 2400, the blue part is what gets hidden. The solution for this would be to calculate the height based on the width, the inverse of our approach. However, this only affects a residual amount of people. Also, we parameterised each significant variable for the posters, so we could easily and quickly change the posters to fit multiple contexts and media. The online exhibition is publicly accessible at (student.dei.uc.pt/~rgoncalves/Website/). The code developed in the context of this work is publicly accessible in this online repository: (github.com/sergiomrebelo/interactive_moving_poster).

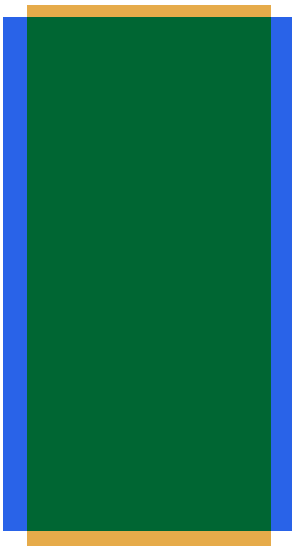


Figure 4.2.2.
Subtitle section on the Biodiversity Loss poster

4.2.1 Noise Pollution

The Noise Pollution posters, as the name implies, tackle environmental Noise or Sound Pollution. Noise Pollution is an invisible danger increasing worldwide alongside industrialization and the growth of urban spaces. Noise Pollution is often disregarded as a serious topic, opposed to more mainstream environmental problems, such as Water and Air Pollution (Nathanson, 2020).

Noise Pollution definition is the exposition to an undesired, excessive sound level. Nonetheless, not every sound is considered noise. The World Health Organization (WHO) defines a sound above 65 dB (decibel) as noise pollution (Berglund & Lindvall & Schwela, 1995).

The most prominent sources of noise come from human activity such as transportation (*e.g.* Air, Rail, and Road traffic), construction activities, industrialization (*e.g.* factories), and social gatherings (*e.g.* restaurants, bars, concerts, and terraces). For these reasons, Noise Pollution is a problem often associated with larger metropolitan areas (Nathanson, 2020).

Continuous exposure to higher decibel sounds can cause various health problems such as high blood pressure, heart diseases, sleep disturbances, and stress. Noise-Induced Hearing Loss (NIHL) is the most common consequence. Unfortunately, humans are not the only ones affected by this problem. Noise Pollution impacts the health and well-being of wildlife, both on land and in the water. Sound is an essential part of an animal's life, whether navigating, finding food, attracting mates, or avoiding predators. An example of that is dolphins and whales that rely on echolocation to perform basic survival tasks, such as communicating, hunting, navigating, and finding mates. The excessive sound makes it harder for animals to achieve those basic tasks successfully, and consequently, endangers them (Carrol, 2019).

An article also showed us that noise disturbed birds and caused them chronic stress, affecting their development and growth from youth and significantly reducing their life expectancy (Hoose, 2018; Kleist et al., 2018).

Exceptionally, we developed two posters for the issue of noise pollution, exploring two different subjects related to this thematic into two different approaches. Although we developed the two completely functional posters version for visualization, we decided in the exhibition only to present the first experiment (Noise Pollution Poster #1) since it, in our opinion, transmits the message more efficiently.

Noise Pollution #1
The main objective of this poster was to display the user's environment sound/noise and simultaneously show that the louder the noise is, the more harmful it is to our health. Our first concept to accomplish this was to display the word noise in a deconstructed way, slicing the word into segments, and displaying those segments at a time, according to the input volume, in a way, acting as a sound-level graph. The second step was to add some indication/feedback to the user that the louder the sound, the more harmful it becomes.

The first iteration of this poster was very straightforward. We created the first design deconstructing the word *noise* into slices and created a mask out of it. We created a black rectangle behind the mask for the animation and changed its size according to the input value.

To display and demonstrate the harm of noise pollution, we decided to add a noise texture to the poster. For the texture, we tried to create a Dotted Halftone Pattern, where the texture (dot size) increases depending on the volume level. The first attempt/version we implemented had to cycle through every 10 pixels (arbitrary number chosen by us) of the poster and transform those pixels into dots. The size of each dot depends on how dark the specific pixel was on a grayscale. If the

pixel were black, it would be the maximum size; on the other hand, if the pixel were white, it would be nearly invisible. The biggest problem with this implementation was, apart from visually not achieving our intended results, the continuous cycles through the poster pixels made the program run very slow.

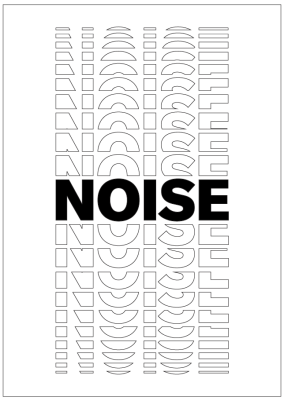


Figure 4.2.1.1
First version of the Noise Pollution poster (1/3)

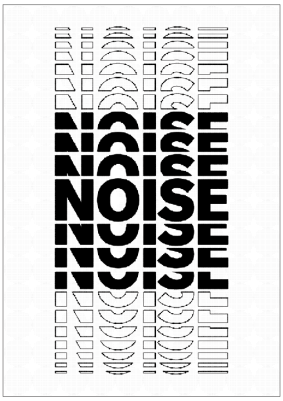


Figure 4.2.1.2
First version of the Noise Pollution poster (2/3)

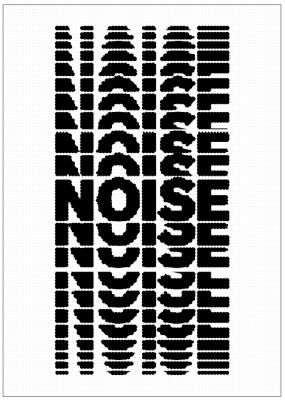


Figure 4.2.1.3
First version of the Noise Pollution poster(3/3)

For the second and final version of this poster, we started by redesigning the word Noise (Figure 4.2.1.4), but instead of creating an image mask, we decided to split each segment of the word noise into its image file (in this case, a PNG file).

This way, we can divide this poster into two parts. The first part was to grasp the audio input from the used microphone and animate the poster with it. The microphone sound values in p5.js audio go from 0 to 1. To make these values more manageable, we mapped those values from [0 - 1] to [0 - 1200]. Having the sound mapped, we created various if statements to display a specific image/shape at different sound ranges. For example, when the sound is between the values of 0 and 100, we show the word noise, if the sound reaches the second range of 101 to 200, we show one more shape above and below the word Noise, and so on, until the last sound range of 1200+.

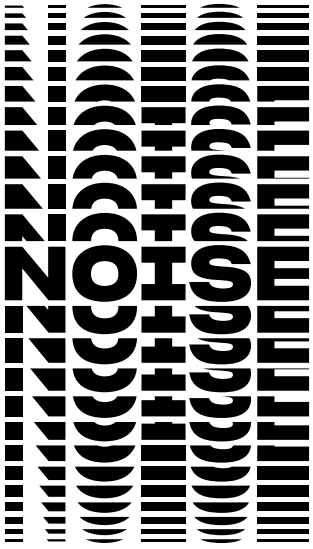


Figure 4.2.1.4
Design with the word *Noise*

For the second part of this poster, we had to implement the dynamic Dotted Halftone Pattern texture. We developed the static texture firstly using the Javascript and P5.JS library (which was too heavy to compute by browser and, consequently, slow the poster designs) and secondly using only a CSS language, based on the CMYK Halftone Pattern code snippet from platform Codepen (codepen.io/coreh/pen/LQJBLa) (which was more lighter to computer by browser). In this process, we adapted the initial texture to our necessities, modifying visual features such as the contrast, the dots size, and the blend mode. We achieved great visual results using black and white and the CMYK colour system (Figure 4.2.1.5 and Figure 4.2.1.6).

Figure 4.2.1.5 and Figure 4.2.1.6
Experiments with the Noise texture

After having the static texture implemented, the animation was still missing; we wanted to change the texture intensity according to the sound input. We started by creating a CSS variable for the blur filter property. This way, when this property is changed, it enables us to easily adjust (increase and decrease) the distortion added to the poster.

This parameter (blur) enabled us to change the dot's size. We mapped the sound volume to the blur intensity while simultaneously updating the CSS blur variable in real-time. This resulted in a very fitting texture. Not only did it visually accomplish our visual expectation of the poster as well as it completely distorts the poster when the sound reaches a certain range. So, this enabled the poster to convey our main conceptual message goal visually (i.e. loud noises can be very harmful to our health and wildlife).

The interactive version of this poster may be accessed in <student.dei.uc.pt/~rgoncalves/PosterF/>. Also, an animated version of the poster can be visualised in <youtu.be/muVxfcmmXeY>. Figure 4.2.1.7, 4.2.1.8 and 4.2.1.9 on the next page display the static versions of this poster.

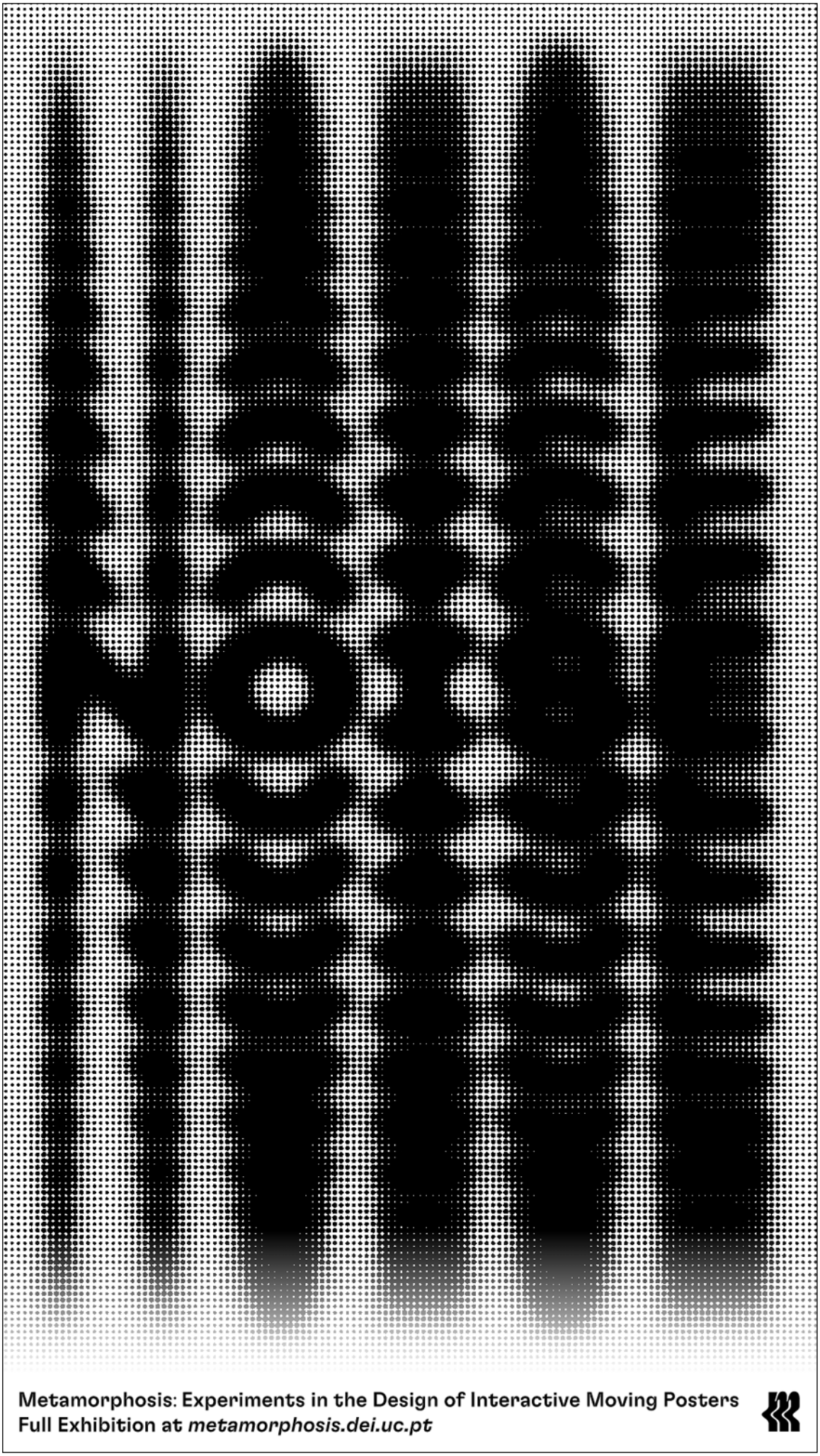
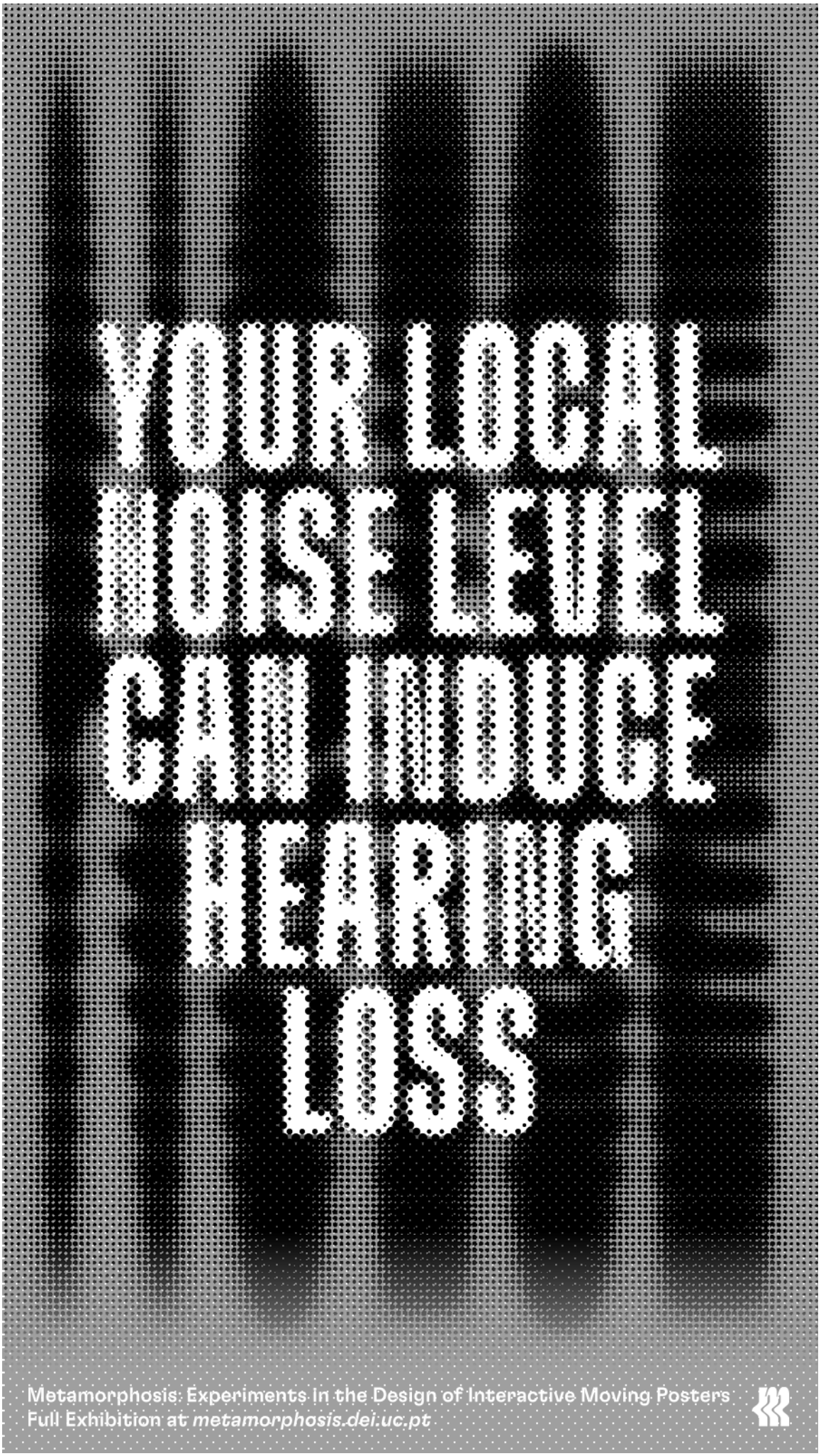

Metamorphosis: Experiments in the Design of Interactive Moving Posters
Full Exhibition at *metamorphosis.dei.uc.pt*

Figure 4.2.1.7


YOUR LOCAL
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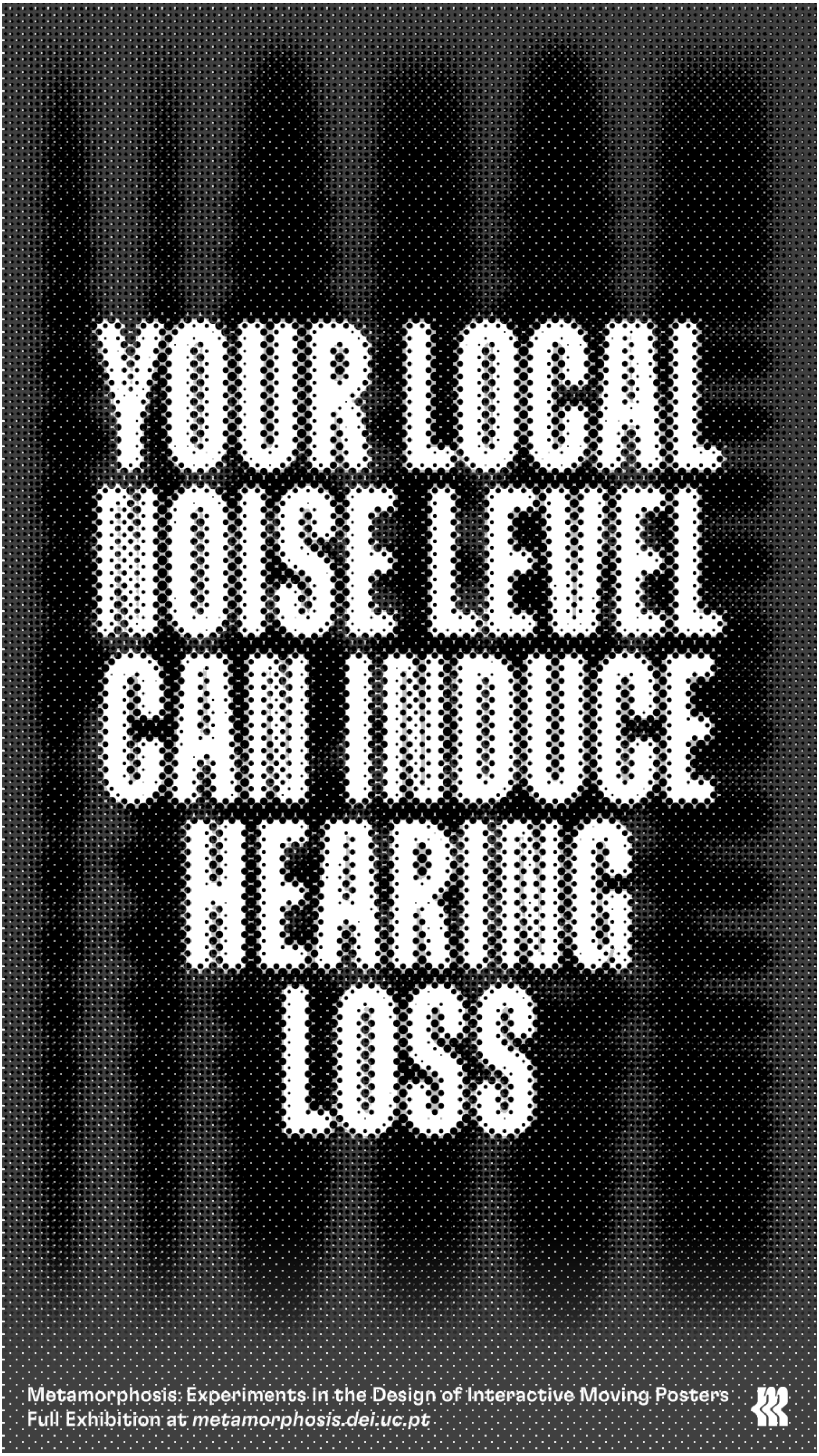
Metamorphosis: Experiments in the Design of Interactive Moving Posters
Full Exhibition at metamorphosis.dei.uc.pt

Figure 4.2.1.8


YOUR LOCAL
NOISE LEVEL
CAN INDUCE
HEARING
LOSS
Metamorphosis: Experiments In the Design of Interactive Moving Posters
Full Exhibition at metamorphosis.dei.uc.pt
Figure 4.2.1.9

Noise Pollution #2

The concept for this poster was to explore the complementary relationship between Silence and Sound (or Noise), displaying both words (silence and noise) on the poster at all times, using a heavier weight or Bold font to represent the word *Noise*, and lighter font to represent the word *Silence*.

The poster animation consists of changing the height of each word according to the sound captured from the user's environment. We decided to develop this poster using vanilla HTML, CSS and Javascript, manipulating a variable font. The louder the sound captured, the taller the word *Noise* will be. In contrast, the shorter the word *Silence* will be. The same thing applies when the sound captured lowers. It makes the word Silence increase and the word Noise decrease in height. That is, the sum of both heights is always the height of the poster, making them proportional in size.

After the concept definition and before the implementation, we needed to find a variable font to use, which is when the struggle started. We had to find a variable font with either a width axis that enabled us to condense and increase its height or a font with a built-in height axis, which is rarer since most variable fonts have a ″width″ and ″weight axis″.

After lots of unsuccessfully searching, we decided to try and create our variable letters on Processing (Figure 4.2.10). However, soon we realised that it would not be feasible to create all letters necessary to write the two words manually and their light and bold versions. The whole process would be very time-consuming, and some letters, especially the letter ′S′, would be very intricate to create, considering their curves.

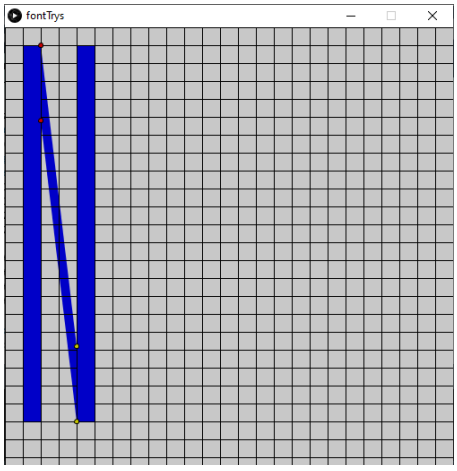


Figure 4.2.1.10

However, soon after, we found the Chicken Shop Gothic variable font, designed by Lewis McGuffie, in 2018 (typeverything.com/project/chicken-shop-gothic) that serves our purposes. The only downside of it was that it only has one weight, so the idea of using a bold and light weight to make both words contrast visually was discarded. Instead, we decided to use the word Silence in white with a black border.

Regarding the implementation, the process was reasonably straightforward. We started by capturing the sound as an input. Then, we created a <p> (paragraph HTML element) for each word. The next step was to map the height of each word to the volume level. That is, when it registers maximum volume, the word Noise should be at its taller version, and the word Silence should be at its shorter version, and when it does not register any sound, the opposite should happen. We changed those values through the use of CSS variables, creating an accordion-like effect with typography. The last thing we had to do was to add a translation in the Y-axis to the word Noise since it was aligned to the top. Since the word Silence was aligned to its baseline, no translation was needed.

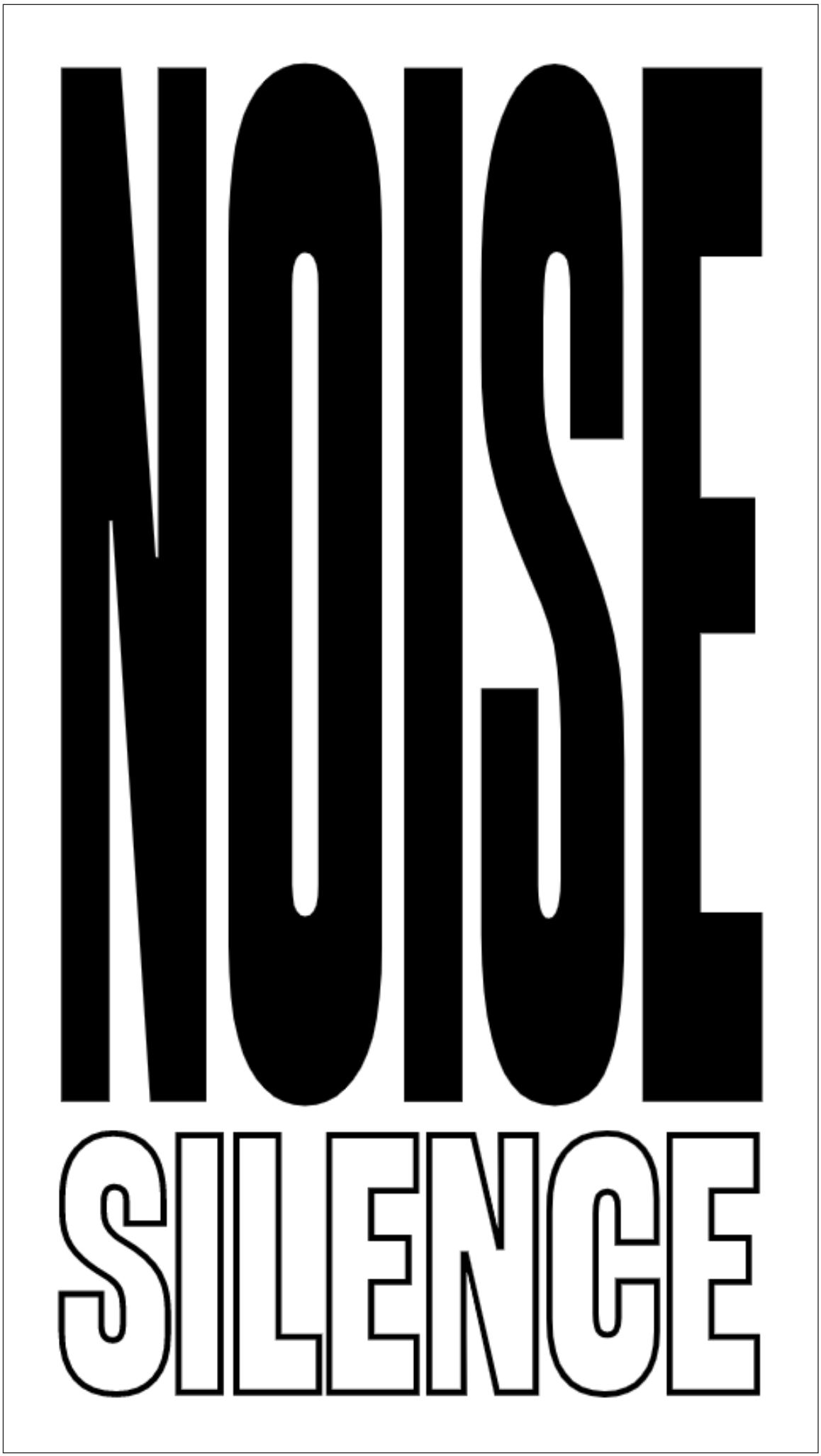


Figure 4.2.1.11

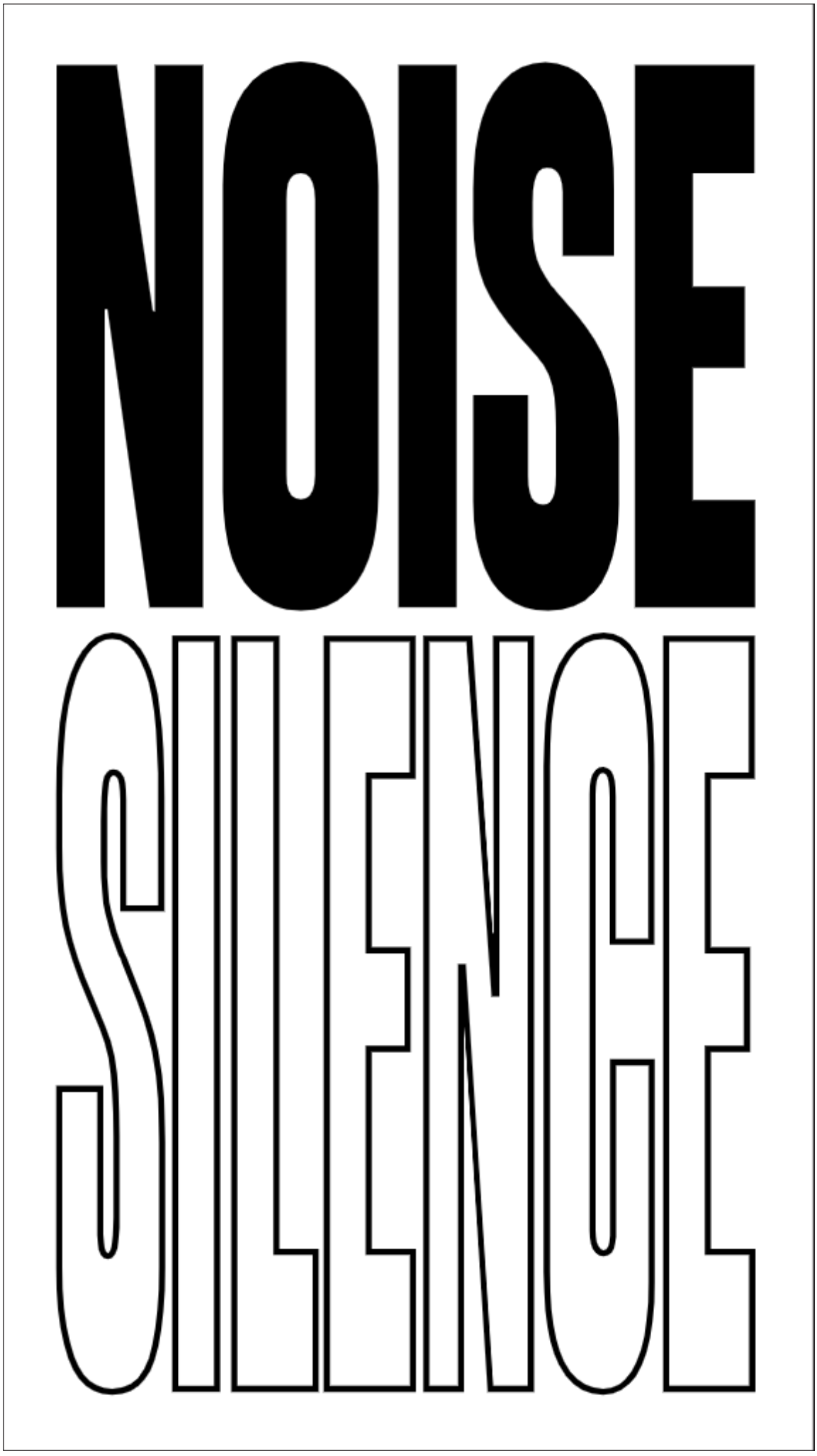


Figure 4.2.1.12

4.2.2 Deforestation Poster

Forests cover 31% of the land area available on our planet. They are a vital factor for the world's health. Forests provide cleaner air through the process of photosynthesis, absorbing Carbon dioxide (C02) and releasing Oxygen, playing a critical role in mitigating climate change. Forests are typically carbon sinks, that is, places that absorb (through photosynthesis) more carbon than they release (through respiration). Once a significant dismantling of trees happens, these zones can go from carbon sinks to carbon sources (Carrol, 2020).

Figure 4.2.2.1
Available at https://www.nationalgeographic.org/encyclopedia/deforestation/

Although water covers about 70% of Earth's surface, less than 3% of it is fresh water, and the rest is saline and ocean-based, not fit for human consumption. Of that 3% of freshwater or so, less than 1% is easily accessible. The rest is frozen in glaciers and ice caps. For this reason and many others, forests are essential since they provide clean water by capturing rainwater and recharging underground aquifers (Carrol, 2019).

Forests are home to 80% of terrestrial biodiversity; that variety is especially rich in tropical rainforests. They are also a source of livelihood (food and shelter) for many different human settlements (300 million people live in forests worldwide), including 60 million indigenous people. Consequently, deforestation can diminish those listed benefits and endanger the lives of millions of humans and thousands of species (Derouin, 2019).

The reasons for deforestation can vary from region to region. Moreover, it is widely known that most causes are directly or indirectly caused by human activity. The most prominent causes are logging, agricultural expansions and cattle breeding (the result of an increasing human population and its needs), infrastructure development (urbanisation), extractive activities (e.g. mining, oil, and gas extraction), and wildfires. The current high human consumption of fossil fuels (e.g., coal, gas, and oil) is releasing back into the atmosphere CO2 that was removed from the carbon cycle since prehistoric times and has been stored below the surface for thousands of years. Also, humankind is cutting the living beings (trees) that help control and reduce the amount of CO2 in the atmosphere by performing carbon sequestration (Derouin, 2019; Nunez, 2019). This way, currently, we are experiencing a degradation of air quality worldwide.

To put in perspective how worrisome is deforestation to air quality, according to the World Resource Institute (Gibbs & Harris & Seymour, 2018), a nonprofit environmental organisation, if tropical deforestation were a country, it would rank 3rd in CO2-equivalent emissions, only behind China (1st position) and the United States of America (2nd position).

The Deforestation Poster seeks to demonstrate the importance of trees and the consequences of their destruction to our environment. Although most people know that trees can produce Oxygen through photosynthesis and, i n return, store carbon, most do not know that

when a tree is cut or burned, it releases back into the atmosphere the carbon and other pollutants stored inside it. This greenhouse gas can transform the Global Climate and accentuate other environmental problems (Pimm, 2007).

We thought of representing a forest metaphorically in our poster through the use of three tall pine trees. These trees will stay untouched until the presence of a human. Once a human appears in front of the poster, each tree will fall, one by one, until there are only three stumps left, trying to alert, therefore, that humans are responsible for the destruction of forests. In the end, when every tree in the poster is cut and turns into a stump. The poster presents one of the consequences of deforestation mentioned before: the release of CO2 back into the atmosphere. To demonstrate that, we decided to add smoke particles appearing from the centre of the stump. The smoke is a metaphor for industrialisation and how the stumps turn into small chimney factories, in a sense that both are harmful to air quality to each extent when releasing CO2 and other gases (Figures 4.2.2.1 and 4.2.2.2). We also display a message simultaneously with the smoke, showing an estimated number of hectares lost in the current year.

Figure 4.2.2.1
Visual metaphor
Available at https://pixy.org/5875589/

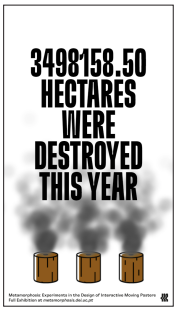


Figure 4.2.2.2
Visual metaphor

In the implementation of this poster, we started by creating various illustrations of trees and trying to balance simplicity and detail. We needed the illustration to be simple enough to make the process of animating the trees being cut easier, but also detailed enough to make them easily recognised by the user as a tree.

After having all the designs created and selected, we started by placing each tree in place and animating them being cut. To accomplish that, we resorted to a simple sequence of geometrical transformations. First, we divided the tree image into two, then we rotated the top part of the tree, using the top right point of the stump as a rotating point. Firstly, we did a translation to the previously defined rotation point, and then we executed the rotation while simultaneously adding opacity to the tree until the tree disappeared.

The next step was to find the best way to activate those animations. Since the causes for deforestation are almost all human-made, it came almost naturally to use Face Detection since it is the best way to detect if a human is facing the poster or not.

We decided to use machine learning, more specifically the pre-trained PoseNet model. Posenet (tensorflow.org/lite/examples/pose_estimation/overview) is a machine learning technique (a deep learning TensorFlow model) (tensorflow.org) that detects and tracks human poses in real-time. Posenet model uses an image/video as an input and returns an array of coordinates (x, y) with a confidence score (from 0 to 1) to a list of predefined key points (17 in total) on a Posenet skeleton (e.g. “nose”, “left wrist” and “right ankle”).

Using the popular Javascript libraries P5.js and ML5.js (ml5js.org/), a machine learning library for the web browsers, built on top of

TensorFlow.js, we were able to implement Posenet successfully. As mentioned before, Posenet returns as an output, a confidence value for the pose, from 0 to 1, or in other words, how certain it thinks it is recognising a person. It also returns a list with all the pose key points, their x and y coordinates, and their confidence score (Figure 4.2.2.3). Since we only wanted the face detection, we used the score of all the key points available on the face, the “left eye”, “right eye”, and “nose”. If those three scores are simultaneously above 95% assurance, a boolean variable becomes true, and we use it to check if a person is being detected.

Figure 4.2.2.3
List of key points and their values received by Posenet

The next step was to implement the smoke particle system. For that, we adapted a “Simple Particle System” example created by Daniel Shiffman (thecodingtrain.com/CodingChallenges/078-simple-particle-system.html). We changed particle velocity, lifespan, randomness, and texture parameters to achieve the best balance between visual realism and performance. We created a particle system for each tree, so once all trees are cut and a face is detected, particles will appear from the centre of each stump (Figure 4.2.2.4).

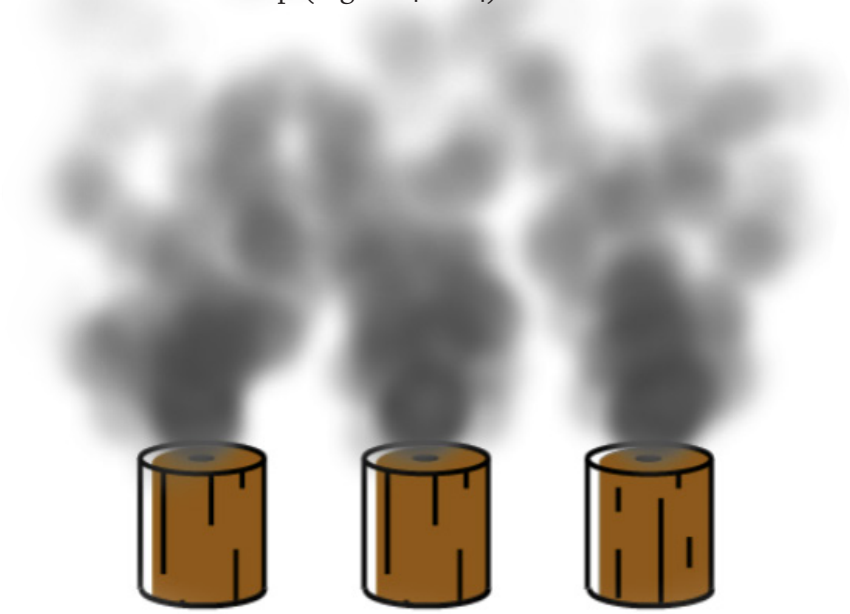


Figure 4.2.2.4
Screenshot of the smoke animation

Finally, we added the message on the poster that displays an estimated number of trees destroyed in the current year. We retrieved the current day number with a Javascript function and then searched the number of hectares destroyed in the past year (2020). Having those two values, we could map the amount of deforestation in the present day (Weisse & Goldman, 2020). Furthermore, We update the number each second, dividing the number of hectares destroyed per year by 365, to get the daily amount by 24, to get the hourly rate and then two times by 60 to get minutes and finally the amount of destruction by the second. To achieve that, we created a <p> (paragraph HTML element) and updated its content each time the draw function ran (Figure 4.2.2.5).

Figure 4.2.2.5
Poster’ message

The most time-confusing and challenging part of the development of this poster was the part where we assembled all the parts developed beforehand. This way, we create multiple conditional statements and

booleans to ensure that all animations run accordingly as expected and idealised, *i.e.* make sure no animation runs simultaneously. The trees are cut one by one from right to left. After some time without detecting the human presence, the trees grow back. To regrow the trees, the poster's system makes sure that all smoke particles have disappeared (more technically, detects if they have been removed from the array) and, subsequently, it regrows the trees from left to right.

To summarise how the poster works, the poster starts with the three trees standing. They will only get affected once a person is facing the poster; once that happens, each tree is cut one by one from right to left. Once all trees are cut, particles release from each stump (particle system) while simultaneously showing the message. Once the human's face stops being detected, all the progress goes backwards. Therefore, the tree "stops" launching particles, and the message starts to fade away. Once both the message and the particles in the poster disappear completely, all trees regrow from left to right. If the face suddenly stops being recognised while the middle tree is being cut, the middle tree will regrow once that animation stops, and the right tree will follow until the poster returns to its default position.

The interactive version of this poster may be accessed in <student.dei.uc.pt/~rgoncalves/PosterC/>. Also, an animated version of the poster can be visualised in <youtu.be/upxQSdpOCh0>. Figure 4.2.2.6 and 4.2.2.6 on the next page display the static versions of this poster.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HECTARES
WERE
DESTROYED
THIS YEAR
Metamorphosis: Experiments in the Design of Interactive Moving Posters
Full Exhibition at metamorphosis.dei.uc.pt

Figure 4.2.2.6


349158.50
HECTARES
WERE
DESTROYED
THIS YEAR
Metamorphosis: Experiments in the Design of Interactive Moving Posters
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Figure 4.2.2.7

4.2.3 Water Pollution Poster

Water covers up 71% of the earth's surface, while 29% consists of continents and islands. Apart from the vast amount of water available, only a fraction of the total water (around 1%) is safe and ready to be consumed (i.e. freshwater). All forms of life (i.e. every organism we know) directly or indirectly depend on water to survive, making water resources essential for maintaining an adequate food supply and a healthy environment for all living organisms. Nowadays, Water Pollution is one of the most destructive and challenging environmental problems to solve (Kiliç, 2020).

Figure 4.2.3.1
The Great Pacific garbage patch
Available at https://voonze.com/the-great-pacific-garbage-patch-the-garbage-island-as-big-as-the-usa/

Briefly, Water Pollution can be described as a release of substances into bodies of water (oceans, lakes, rivers, etc.) that make water unsafe for human use and/or disrupt aquatic ecosystems (Nathanson, 2010).

While Water Pollution causes can be of natural origin, most of them are anthropogenic (i.e. man-made causes). Also, most types of pollution eventually end up affecting the water quality. Air pollution chemicals can pollute water bodies, either by falling due to gravity or through acid rains. Land Pollution substances (chemicals) that originate in crop farms through the use of fertilizers and pesticides can seep into an underground stream (aquifers) that will invariably end up in the ocean (Denchak, 2018).

Some of the biggest and most talked-about causes of Water Pollution are related to the improper disposal of waste, especially plastic pollution, caused by single-use plastics. While many of these plastic products, such as plastic bags, plastic bottles/caps, and food containers, have a lifespan of a few minutes to hours in the consumer's hands, those can have a harmful stay on the environment through thousands of years. Either through suffocation or ingestion, plastic kills thousands of animals each year, harming organisms (regardless of its size) that encounter in its path, from small corals to colossal whales ("The plastic problem", 2020).

The problem gets worse once the plastic reaches the ocean. In the ocean, plastics get disintegrated by the salty water and the sunlight, transforming a single piece of plastic into a series of separate pieces of plastic, the microplastics. These nearly invisible pieces can be found almost anywhere due to their lightweight, from the air we breathe to the food we eat, such as seafood and salt (Parker, 2019; IQAIR, 2021).

Figure 4.2.3.2
Photography of microplastics
Available at https://royalsociety.org/topics-policy/projects/microplastics-in-freshwater-and-soils/

The idea behind this poster was to show the overwhelming amounts of trash that reside in our oceans while simultaneously displaying the items most found as well as their decomposition time. The poster represents a fraction of the ocean. During the user's interaction, we aim to alert the viewers that the waste they produce, and it is not recycled, will probably end up in the ocean. Also, we have the objective of stimulating an experience when the viewers try to clean the trash out of the poster, which will not be possible since, once the trash leaves from one side, it appears on another. In this sense, we convey that it is easier to stop polluting than to solve the problem.

We started the development of this poster by searching the top ten most found items in the ocean. After retrieving the information, we created an array (list) of objects for each of the ten items (Jabril, 2019). The list is the following: cigarettes; food wrappers; beverage bottles; plastic bags; lids; plastic cutlery; straws; glass bottles; beverage cans; and paper bags.

Having the total amount of trash recovered and the amount found for each item, we calculated the probability (between 0 and 1) of each item to be found on the ocean and added that value to the objects. To accomplish that, we used the Pool Selection method, enabling us to select an item based on its probability of being chosen. We implemented the version of a poll Selection method based on the method presented by Daniel Shiffman (youtube video: https://www.youtube.com/watch?v=ETphJASzYes&t=514s). This function starts by choosing a random number (variable named r) between 0 and 1. Iteratively, we remove from the variable 'r' the probability (number) of each item until the variable 'r' number is equal or inferior to 0. Once that number was not above 0 (equal or inferior to 0), it would return the position (index) of the chosen item on the array. For example, if we had only three items on the array, the first one with a probability of 40% (0.4), the second one with a 25% (0.25) of being chosen, and the last one with a 35% (0.35) probability of being chosen. If the randomly chosen number were 0.63, we would go through the three items array, removing their probabilities while the variable 'r' number is above 0. First, it would remove the first item's probability (0.4), making the number 0.23; it keeps going since it is still above 0. Then it would remove the probability of the second item on the array (0.35), which would make the number -0.12, so as the number is not above 0, we would stop the iteration and return the index of the array, in this case, index [1].

After implementing the Pool Selection method, we decided that the poster's system will "launch" a new item into the poster every 10 seconds (number chosen by empirical exploration). As a visual representation for each item, we created an array of images for each trash item and, then, the system randomly selected and displayed one of the images. After adding the items to posters, we thought it made sense to remove them, based on each item's decomposition time, i.e. the paper bag is the item that stays the least time on the poster, and the glass bottles are the item that stays the longest. As the discrepancy between the decomposition time of the paper (2 to 6 weeks) and glass (1 million years) are enormous, we decided to use a logarithmic function (base 10 logarithm) to map those times. As we can see in the Figure 4.2.3.3, the function quickly atenuates, being ideal for this context.We are still able to perceive the items that take less and longer time to decompose. However, the difference in screen time between each item is more balanced.

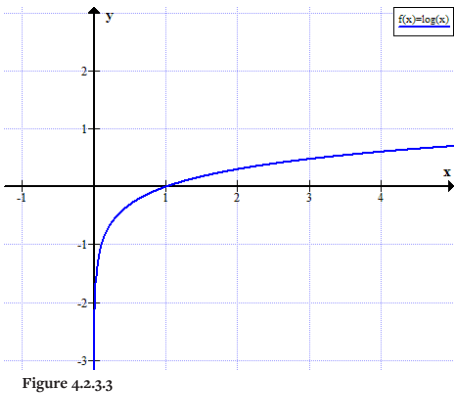

Figure 4.2.3.3
Graph of y = f (x) = log10(x)
Available at https://www.rapidtables.com/math/algebra/logarithm/logarithm-graph.html

We decided to change the background colour of the poster according to the amount of trash present. The concept is, as the number of trash increases, the quantity of chemicals and consequently the water quality decreases, so when the poster has 0 items, the colour is a light blue, when the poster has 40 or more items, the background colour is a dark blue since humans can associate a light colour to something cleaner and a darker colour to something dirtier (Figure 4.2.3.4 to 4.2.3.6).

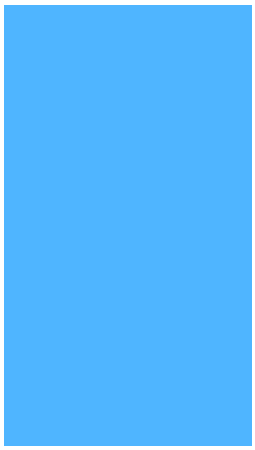

Figure 4.2.3.4
Background colour with 0 trash

Figure 4.2.3.5
Background colour with 20 items of trash

Figure 4.2.3.6
Background colour with 40 items of trash

After having the basic poster functioning, we decided to add the library matter.js, a 2D physics engine for the web. This library enables us to save some time since it already helps to implement some physical mechanics such as calculating the collisions between items by measuring the distance between the centre of each. The default version of matter.js does not let objects overlap, so we need to change some parameters and preferences.

We decided to use the Matter.js library instead of other libraries due to its popularity and the amount of documentation and examples on the website with free source code. In this poster, we also used the p5.js library. The four main components (module aliases) of matter.js are the Engine, Render, World and Bodies. Matter.js has its built-in renderer and runner. We discarded this option since we are using p5.js to run our projects. There is not much to say for the Engine part since we only had to initialize it and create it (brm.io/matter-js, 24-08).

Next, we developed the methods to add the" bodies" to the "world" and see them interact with each other, using the physics settings on the environment. These "bodies" have multiple methods (ways of creating a shape). They can be a rectangle, circle, polygon, trapezoid, and even a custom shape.

Briefly, when adding an item to the poster, we also created a new "body" using the image's width and height. This body behaves like an invisible hitbox. In the end, we add each body to the "world." We just had to make sure the displayed image coordinates were the same as the created body.

In the first explorations, still not using Matter.js, we placed each item at a random location on the poster's canvas. Each time the poster's

run, it adds a random value between -3 and 3 to the X and Y coordinate, making the movement look unrealistic and choppy. Nevertheless, in this second and last exploration, we used a physics engine to make the items movements look like they were underwater fluctuating. In this sense, we began by entirely disabling gravity in the physics engine since objects underwater give the illusion that gravity is nonexistent due to buoyancy that mostly (but not completely) balances out gravity. We also changed some of the Bodies' physical properties, such as density and air friction, to increase the realism of object motion (Davis, 2019).

After some discussion, we thought adding items from the top part of the canvas made sense to look like the items were being inserted into the ocean from above. With this implementation, we had to ensure the initial angle was facing downwards (3 ϖ/2 in radians or 270º in degrees) to ensure the object entered the poster.

Using the physics engine, the object's movement was also completely redone. We started by adding a constant velocity to each object. The only thing that changes in the movement is the angle of direction. As mentioned before, the items start above the poster with a 3ϖ/2 angle. We increase the angle by ϖ/64 each time the movement function runs. It has a 20% chance of reversing the angle to make the object float around.

Since this poster is supposed to be a small section of the ocean, it made sense not to include walls and let the objects fluctuate through the poster. When an item leaves the poster (for one of the four sides), we change its location to the opposite side, making sure to change the direction angle. For example, suppose the item completely leaves through the right side. In that case, we change its X coordinate to the left side of the poster and position its Y coordinate at a random height.

The interaction of the user with this poster, since the trash items found in the ocean are due to human activity, we decided to launch into the poster (ocean) ten items according to their probability when a face is recognized, trying to raise awareness for the excessive amount of trash the average person produces. The value of ten was defined by empirical exploration. Also, we develop an implementation of a face detection algorithm that when a person's face is detected, it saves it. This way, when a face disappears and reappears, it should not be recognized as a new face being detected. This implementation is useful for environments with lots of people interacting with the poster simultaneously. We adapted a code created by Daniel Shiffman in the Processing language (based on Java) to Javascript (p5.js). The code can be accessed at (github.com/danifslopes/distinctFacesFromPoseNet).

Apart from launching the ten items into the poster, we also displayed a message (Figure 4.2.3.7) saying an estimated amount of trash is dumped into the ocean annually. We made that by creating a paragraph (<p>) HTML element. Once a face is detected, we display the message at full opacity (1) and incrementally remove its opacity until it reaches 0. We update these values through a CSS variable.

Figure 4.2.3.7
Poster message

Towards the end of the poster development, and since Matter.js already implements collisions/physics, we added a way of cleaning the trash out of the poster. Since the items, when leaving one side of the poster, return from the opposite side, the message we end up conveying is that not only is nearly impossible to clean all the trash that resides in the ocean, but demonstrating/explaining that the solution for this problem is not only cleaning but mainly reduce the waste and increasing the recycling percentages.

To achieve that, we created one matter.js object at each wrist key point since the Body model does not have the centre of the hand as a key point. After retrieving the coordinates for each wrist, we placed a fishing net in each. The biggest problem with this implementation is that the detection of the wrists key points are volatile. The user should be distanced enough for the algorithm to see all of its upper body. Even at the ideal distance to the camera, the wrist objects move in a really unstable manner since they do not gradually travel to the new wrists location but simply change their position instantly.

The interactive version of this poster may be accessed in <student.dei.uc.pt/~rgoncalves/PosterD/>. Also, an animated version of the poster can be visualised in <youtu.be/VUGi2bILues>. Figure 4.2.3.8, 4.2.3.9 and 4.2.3.10 on the next page display the static versions of this poster.


10 MILLION
TONS OF
PLASTIC ARE
DUMPED IN
THE OCEAN
ANNUALLY
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Figure 4.2.3.8


10 MILLION
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Figure 4.2.3.9

Figure 4.2.3.10

4.2.4 Global Warming Poster

Climate Change can be described as unstable and complex shifts that affect our planet's weather and climate systems. The components that it affects are: atmosphere (air), hydrosphere (water), cryosphere (ice), lithosphere (earth's surface), and biosphere (ecosystems and living organisms). Despite what most people think, Climate change is not synonymous with Global Warming. Climate Change encompasses rising average temperatures and extreme weather events, rising seas, ice melting, droughts, hurricanes, and many other impacts (Selin, 2021; Ketchum, 2019).

Global warming is the phenomenon of increasing the average earth's surface, oceans, and atmosphere temperature due to an increase in the Greenhouse Effect. The Greenhouse Effect is a natural process that keeps the earth's surface and troposphere (the lowest layer of the atmosphere) warm. It is crucial to sustaining life on the planet since our planet would be 33º Celsius colder without it, transforming the planet into a frozen and uninhabitable place (Revell, 2020).

The most known greenhouse gases are water vapour, carbon dioxide, methane, and nitrous oxide. These gases, like literal glass in a greenhouse, allow visible light from the sun. However, it absorbs and re-emits back down the infrared energy released from the earth, so the higher the concentration of these gases in the atmosphere, the warmer earth can become (Gettelman & Rood, 2016).

While temperature increases are something natural along with the planet's evolution, due to variation in the earth's orbit around the sun, greater distances have resulted in colder cycles, shifts closer to the heat emitter (i.e. the sun) have led to warmer cycles, called interglacial periods. Air pollutants increased the natural temperatures to abnormal values (Kondratenko, 2021).

The Industrial Revolution fostered this problem, when humanity started to burn fossil fuels (e.g. coal, petroleum, and natural gases) in large masses, adding that, to an Agriculture and Livestock expansion, resulting in a large release of gases (carbon dioxide and methane accordingly) into the atmosphere, and consequently increasing the global temperature to uncommon levels. Most of the studies show that the greenhouse gases level is higher than any moment in the last 800 thousand years (Figure 4.2.4.1)(EPA, 2021).

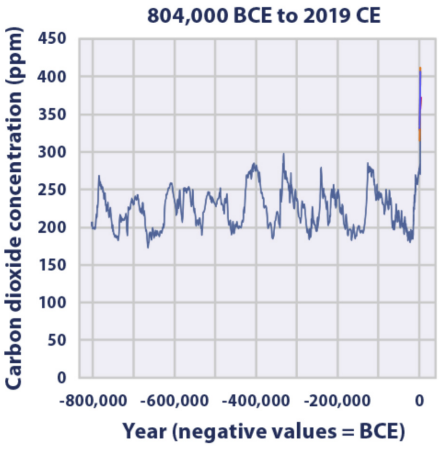

Figure 4.2.4.1
Carbon concentrationin the atmosphere from the last 800 thousand years. Available at https://www.rapidtables.com/math/algebra/logarithm/logarithm-graph.html

As a consequence of global warming, the earth's temperature continues to rise; therefore, we will observe the melt of ice glaciers and the consequent sea level rise, affecting coastal zones and their populations. It will also cause a decrease in freshwater availability since glaciers store around three-quarters of it. It will also increase the impact of natural events, such as hurricanes, which are likely to become stronger. Droughts and floods will become more common. It will also create shifts in ecosystems due to species changing their habitat location to survive. While some species will thrive with the earth's heat increase, like some insects species, for others, life will be heavily endangered,

like polar bears in the Arctic and adélie penguins in the Antartide ("Effects of Global Warming", n.d.).

The concept for this poster is simple. We picked the most notorious consequence of global warming, the melting of glaciers and ice surfaces and the inevitable rise in the sea level. This way, the poster displays the problem's denomination (Global Warming) and melts the word according to the location temperature.

The original concept for this poster was thought for a physical poster setup. The first interaction idea was to retrieve the temperature in the surroundings of the poster by using a temperature sensor so people could use cold and hot items to change the temperature input and directly affect the poster state.

Since the poster will be presented online, we had to find another way of retrieving the temperature that worked online and in the physical world. The alternative we chose was to get the user's local weather temperature. We first ask the users permission to retrieve their location using the Geolocation API. After getting the user's permission, we can retrieve their geolocation (latitude and longitude). Next, we used the online service OpenWeatherMap and their Current Weather API (openweathermap.org/current) to retrieve multiple weather-related information, such as Humidity, Sea Level, and Wind Speed. However, we decided to use only the Temperature parameter.

We started by displaying a rectangle above the words "Global Warming" and changing its height according to the mapped temperature value (Figure 4.2.4.2). For that, we mapped the coldest temperature registered on earth (-89.2º C) to the bottom of the poster (no height) and the hottest temperature measured on earth (56.7º C) to the maximum height (www.currentresults.com/Weather-Extremes). The initial colour for the rectangle chosen was blue, but we thought it made more sense to use warmer colours. We used a variable colour according to the temperature read, going from blue (cold colour) to yellow and then red (warm colour).

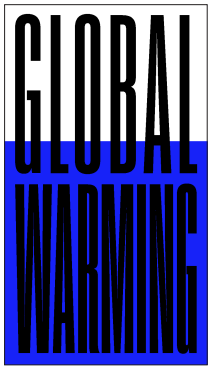

Figure 4.2.4.2
First experimentation only animating the blue square according to the sea level (temperature input).

The most visually important step was to create a text distortion effect that looked somewhat similar to a melting effect. After some time searching, we discovered the SVG filters ("feTurbulence" and "feDisplacementMap"). We used these to create visually interesting effects while using simple code (without Javascript). After some experimenting with all the possibilities that these filters could offer us, we ended up choosing parameters settings that fit our intentions, a wave melting effect while simultaneously adding some text distortion. We also changed the value on *feDisplacementMap* according to the temperature read. The higher the temperature higher the texture distortion. To add this animated effect to the poster, we added two equal images displaying the same content ("Global Warming"), one on top of the other. We added the effect to the top image and then created a mask that changes according to the sea level (temperature input), showing the untouched image below.

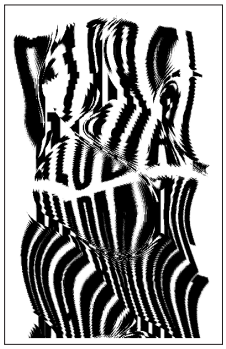

Figure 4.2.4.4
Experimentation with the SVG texture possibilites

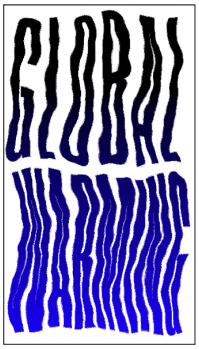

Figure 4.2.4.5
Experimentation with the CSS multiply options

As for the user interaction, we thought it needed to convey another message to the user, apart from displaying a consequence of Global Warming, the sea-level rise. While large companies are the main ones responsible for the greenhouse gases emissions into the atmosphere (climateaccountability.org/carbonmajors.html), especially fossil fuel companies, being Saudi Aramco, Chevron, and Gazprom, the top three companies that contributed more to the carbon dioxide emissions since 1965, according to the Climate Accountability Institute (Taylor & Watts, 2019). We could still change and adopt some behaviours as individuals to reduce our Carbon Footprint (total greenhouse gases, mainly carbon dioxide, released from human activities, from an individual to a company) (Selin, 2020).

Once again, resorting to the same face detection implementation used on the Water Pollution Poster (see subsection 4.2.3). This way, when a person's face is detected, we display the following message "Reduce your Carbon Footprint" to promote a behavioural change of viewer. We also increase the animated effect when a user presents himself to the poster. After some second, both the message and the increased texture fade away, and the poster goes back to its standing state.

Figure 4.2.4.6
Global Warming poster message

The interactive version of this poster may be accessed in <student.dei.uc.pt/~rgoncalves/PosterB/>. Also, an animated version of the poster can be visualised in <youtu.be/L0U6kruQWVw>. Figure 4.2.4.7 to 4.2.4.10 on the next page display the static versions of this poster.

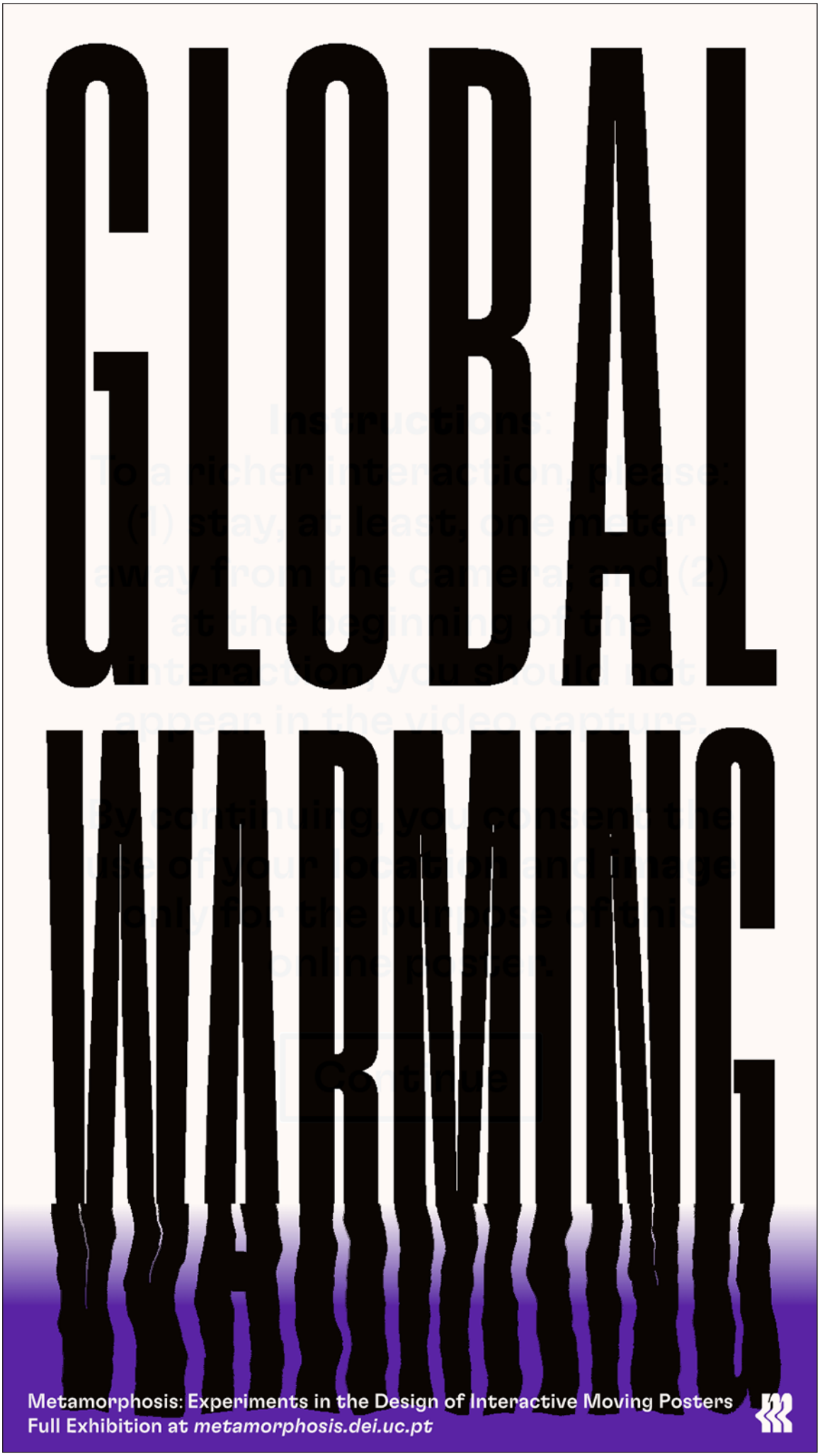
GLOBAL
WARNING
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Figure 4.2.4.7

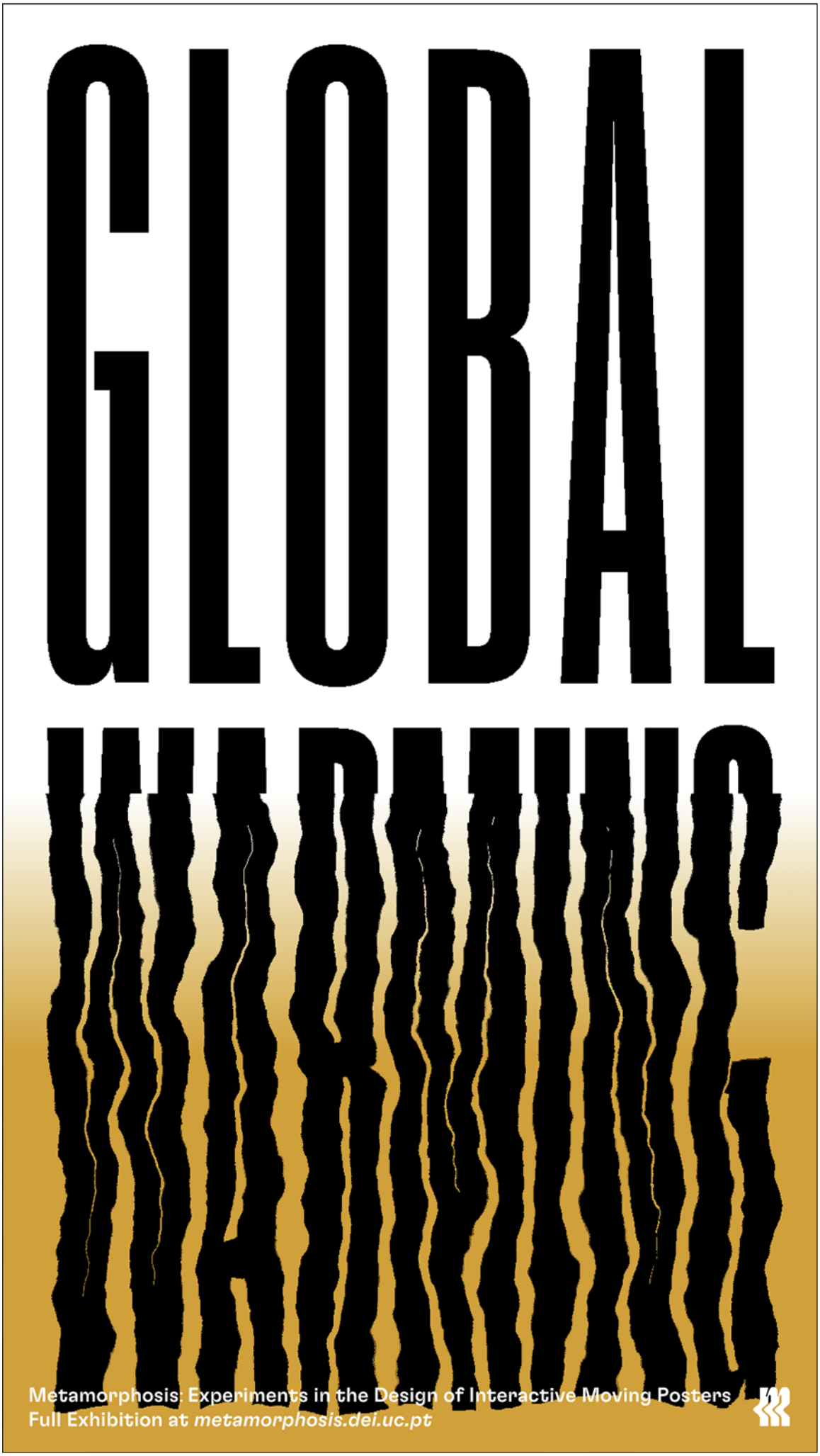
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Figure 4.2.4.8


GLOBAL
WARMING
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Figure 4.2.4.9

Figure 4.2.4.10

4.2.5 Air Pollution poster

Air Pollution is one of the world's largest health and environmental problems. This problem consists of the excessive amount of chemicals or particles that pose a health risk to various living organisms, from animals to plants. These air pollutants can take many forms, such as gases, solid particles, or liquid droplets. This problem can develop in two different contexts: indoor (household and workplace) and outdoor air pollution (Rutledge, 2011; Ritchie & Roser, 2017).

Figure 4.2.5.1
Heavy smog in Dheli, India
Available at https://cen.acs.org/environment/pollution/Searching-solutions-Delhis-air-pollution/97/i7

To understand the gravity of this problem, The World Health Organization (WHO) states that around 91% of the world's population live in places where the Air Quality levels exceed the WHO limits. The consequence of this is that an estimated 7 million people die prematurely every year due to health complications provoked by an excessive amount of air pollutants (World Health Organization, n. d.)

While this problem can be induced by natural sources, such as smoke from a wildfire or ash from volcanic eruptions; however the most common causes are anthropogenic (i.e. human-made). The human-induced causes can occur in the most disparate contexts and activities since different activities release different pollutants. Some outdoor causes include burning fossil fuels to produce energy for electricity or transportation, industrial emissions, construction and demolition activities, transportation, agriculture activities, and garbage waste incineration. In the indoor context, some causes come from chemical and synthetic products that appear in household products and materials; these can be found in paints, cleaners, and personal care products (e.g. perfume and deodorant). These activities release different pollutants, while transportation mainly discharges carbon monoxide (CO), an extremely toxic pollutant that in excessive amounts, especially in closed indoor spaces, can cause dizziness, loss of consciousness. Agriculture activities/processes are the major source of ammonia (NH_3) emissions into the atmosphere; this toxic pollutant can cause immediate burning of the nose, throat, and respiratory tract. (Kumar, 2021; Greiner, 1996; "The Facts About Ammonia", 2005).

The specific and direct consequences of Air Pollution are difficult to define since different gases and particles can cause distinct health problems. To simplify some of the consequences of bad air quality in our health, we will divide them into two parts, short-term and long-term effects. Most short-term effects are temporary and can be recovered, such as headaches, pneumonia, and bronchitis. Long-term consequences are more severe since they can last years to be recovered from or even last an entire lifetime, such as heart diseases, lung cancer, and respiratory diseases (Rutledge, 2011).

Unfortunately, humans are not the only ones getting affected by bad air quality. It takes a toll on all the environment and its living organisms. Air pollution can contaminate the surface of bodies of water and soil, consequently affecting and harming ecosystems. In the same way, it happens with humans; animals can also get diseases caused by excess air pollutants, giving birth defects, life-threatening diseases, and

decreasing their reproductive rates (Rutledge, 2011).

Our first experiment for this poster (Figure 4.2.5.2) was the main aim of demonstrating the levels of pollution in different large cities worldwide. The poster would display six large cities with different pollution intensities and display their AQI (Air Quality Index) value. We would display the six cities in order, from the cleanest city to the most polluted one. Using a variable font to map the AQI level to the font's weight, the more polluted the city and consequently their AQI, the heavier weight the font would have. Ideally, we would choose one city for each AQI range, so a city with a value from 0 to 50, a city from 51- 100, and so on.

Figure 4.2.5.2
Print of the first idea, half implemented

The problem with this implementation was that we could not find any API with a list of large cities and their current AQI. To achieve that, without a list, we would have to fetch individual API links, one for each city, save the AQI values, and add them to an array (list). Then, we would have to go through the array and find the cleanest and most polluted city. It would be a slow and ineffective process. For this reason, we decided to develop a new concept for this poster.

Our second experiment followed the same principles of the Global Warming Poster (see subsection 4.2.4). In this sense, it also displays real-time information about the user's environment, in this case, information regarding Air Quality and its Pollutants amount. We used the online service OpenWeatherMap (https://openweathermap.org/api/air-pollution) and their Air Pollution API. With it, we were able to retrieve the current Air Quality Index, which goes from 1 to 5, being the value "1" Good and the value "5" Very Poor. It also contains several components/pollutants often used to measure and calculate a location AQI. The pollutants we used were Carbon Monoxide (CO), Nitrogen Monoxide (NO), Nitrogen Dioxide (NO2), Ozone (O3), Sulphur Dioxide (SO2), Fine Particles Matter (PM2.5), and Coarse Particulate Matter (PM10).

The first part of the implementation was the message. We displayed the message "Your Location Air Quality Index is", and then, according to the AQI retrieved from the user location (1 to 5), we displayed different words ("Good", "Fair", "Moderate", "Poor" and "Very Poor") in distinct colours ("Green", "Yellow", "Orange", "Red" and "Purple"), accordingly.

The second part of this poster was to represent each pollutant retrieved by the API. We decide to represent them as circles that change their size according to the value read, so the circle will be small if it is a low value and more prominent if the value is high.

Regarding the implementation, we used once again Matter.js which adds physics to 2D objects. We started by adding a body for each of the pollutants and then mapping the input values to access each size. We searched for the values range of each pollutant before mapping. For example, Ammonia (NH3) Good Range is from 0 to 200, and the

Severe Range is above 1800. So we mapped the value zero to the smallest size chosen and the 1800 value to the largest size chosen.

The type of implementation has a problem that transmits the message even better in some extreme cases (Figure 4.2.5.3). The unintentional problem is that when a value for one of the pollutants is way higher than the severe AQI level, the circle diameter can be larger than the width of the poster, making the particles barely move since the poster space is practically filled. We could have used a logarithmic function to map these values, which would prevent this accident from happening. It is an accidentally effective way of demonstrating a bad air quality, in a sense that, if the local pollutants do not even fit the poster, it is hugely concerning for the local's health (Aastha, 2019).

Figure 4.2.5.3
Air Quality Index in Dubai

The last thing we had to assess in this poster was the way to give feedback to the viewer and simultaneously show that the leading causes of this environmental problem are anthropogenic). So we decided, once a person is detected by the face detection algorithm, to launch harmful particles representing the smog caused by the pollution. The smog particles appear from the bottom and pollute the poster, disrupting the viewer's visibility and readability of the poster information. The only way to 'clean' the poster is to stop being visible and recognized by the camera.

To accomplish this, we reused the particle system code created by Daniel Shiffman and used it in the deforestation poster (see subsection 4.2.24). However, in this poster, instead of having a static origin for the particles to appear from, we added the particles at a random x-coordinate location from 0 to the poster width, increasing the particle size and its horizontal variation, creating a more realistic smog effect. The last thing we decided to change was the smog appearance according to the Air Quality Index (1 to 5). To achieve that, we created five particle images (PNG file). We changed the darkness (in a greyscale) according to the retrieved index value, so if the AQI index is 1, we use the brightest particle, and if the AQI is 5, we use the darkest particle.

The interactive version of this poster may be accessed in <student.dei.uc.pt/~rgoncalves/PosterE/>. Also, an animated version of the poster can be visualised in <youtu.be/KEAmkDEXRB4>. Figure 4.2.5.4 to 4.2.5.8 on the next page display the static versions of this poster.

Figure 4.2.5.4
Air Quality in Oslo, Norway (20th October)

Figure 4.2.5.5
Air Quality in Coimbra, Portugal (20th October)

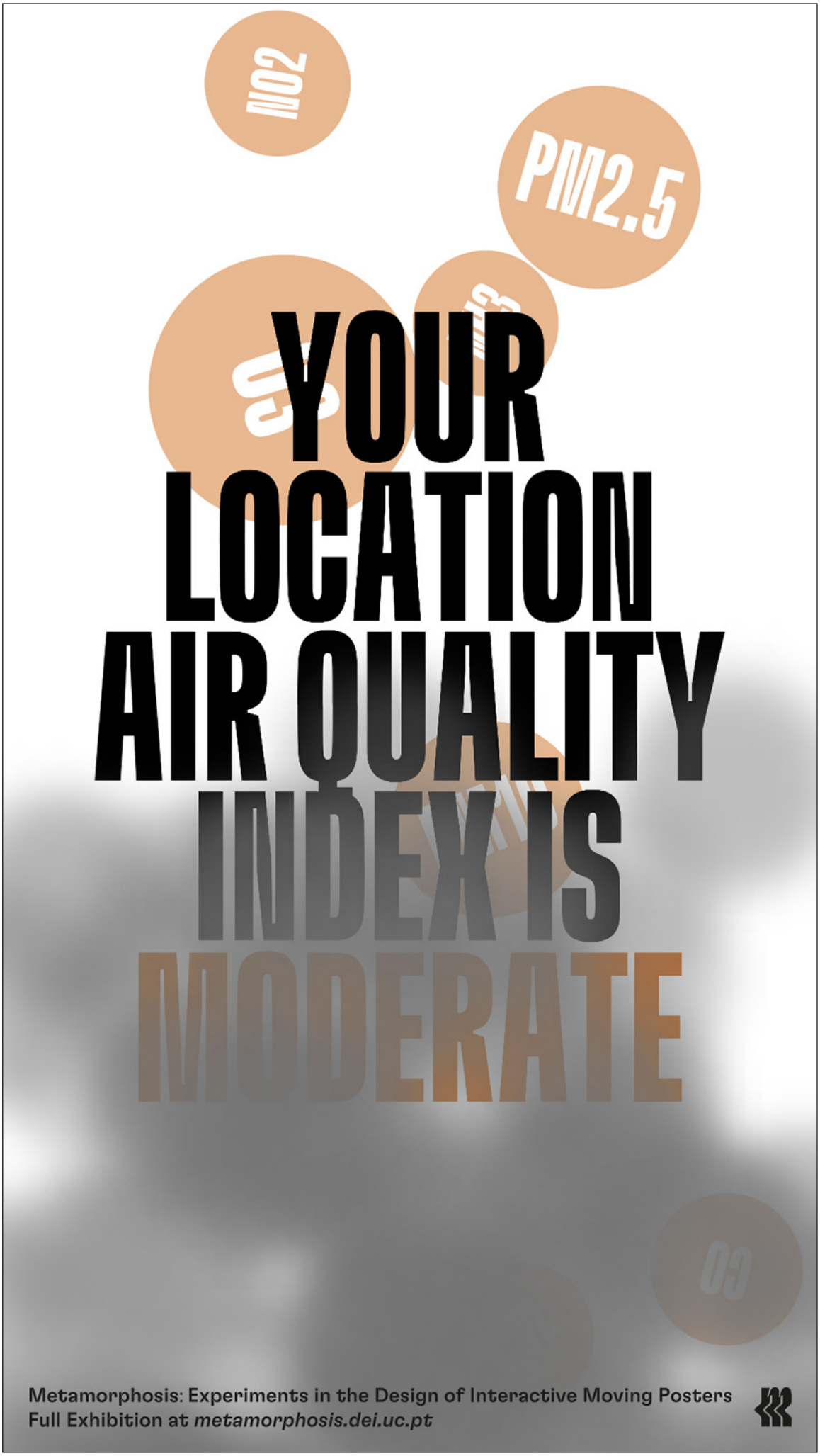


Figure 4.2.5.6
Air Quality in Santiago, Chile (20th October)

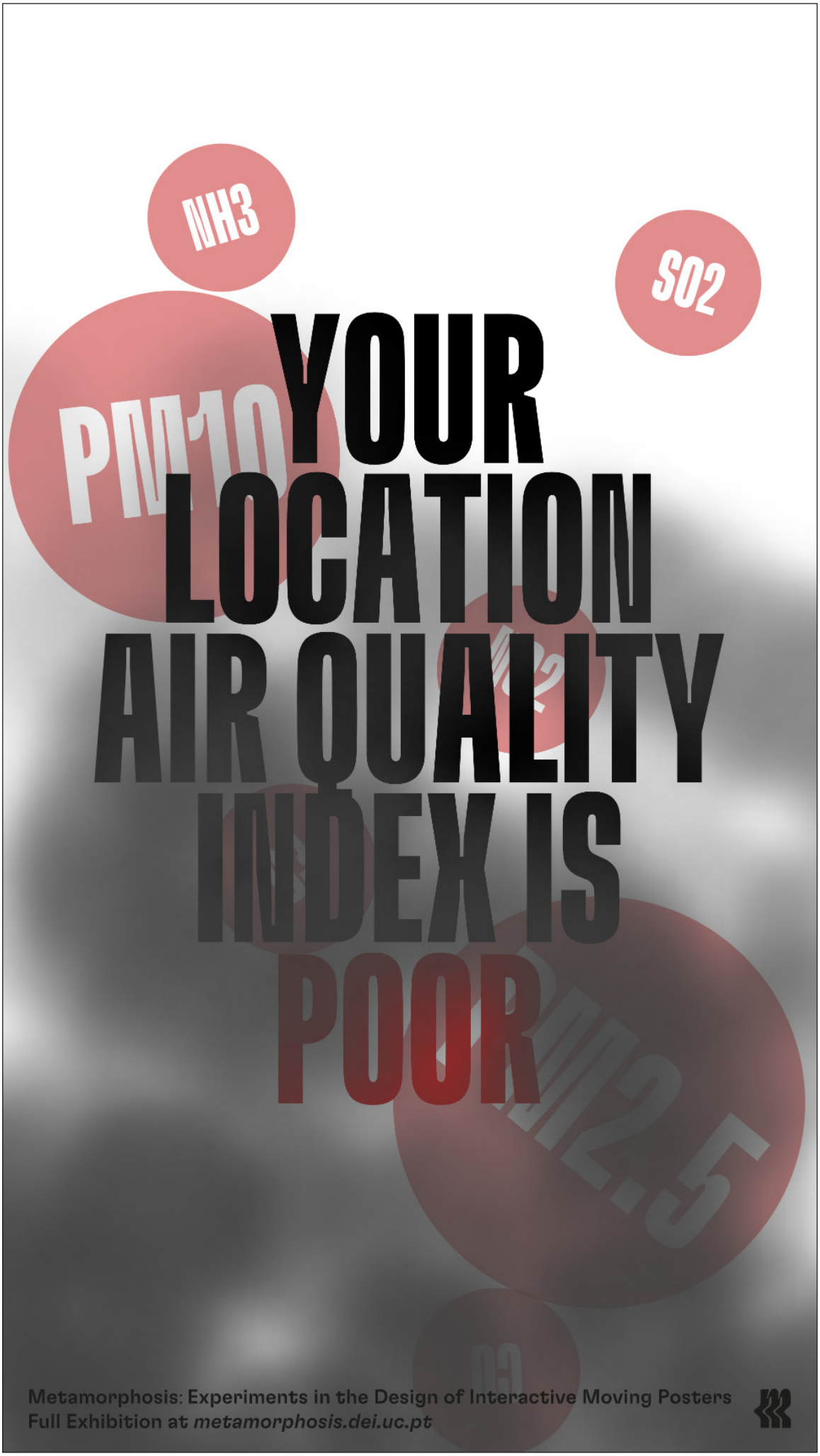


Figure 4.2.5.7
Air Quality in Dubai, United Arab Emirates (20th October)

Figure 4.2.5.8
Air Quality in Dheli, India (20th October)

4.2.6 Waste Poster

Waste is an impactful global issue. We are observing an increasing volume of waste being generated throughout the years due to a rising global population and its living standards. Each year, the world generates more than two billion tonnes of trash. Some studies predict that in 2050, global waste is expected to grow to 3.40 billion (Silpa & Yao & Bhada-Tata & Woerden, 2018; UNEP, 2020).

Figure 4.2.6.1
Open dump surround by seaguls
Available at https://phys.org/news/2018-08-all-you-can-eat-landfill-buffet-birds.html

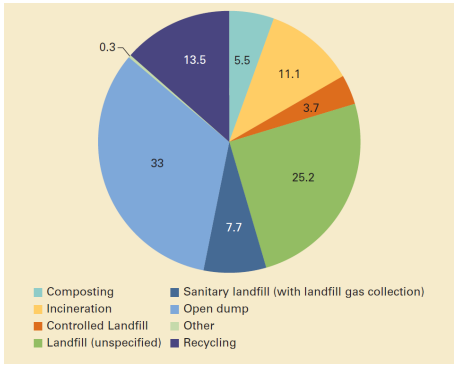


Figure 4.2.6.2
Statistic about the waste management
Available at https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html

Even though recycling and reusing rates are increasing worldwide, the World Bank estimates one-third of the waste generated is still safely managed, i.e., it either ends up in open dumps or the ocean. Sanitary landfills and incineration are not much better options since they also cause significant harm to the environment. If one-third of the waste is mismanaged around the world is already a worrisome statistic, over 90% of it is disposed of in unregulated dumps or openly burned in lower-income countries. Effective waste management is expensive, being the reason it remains a challenge for many developing countries and cities (Silpa, Yao, Bhada-Tata & Woerden, 2019). In the Figure 4.2.6.2 we can clearly see that the better waste management options fall behind one of the worst ones (Open dump).

Although waste is not seen as a major environmental problem, it can affect the environment in multiple ways. Waste, especially in open landfills, can leak hazardous chemicals into the ground, causing Soil Contamination. In the same way, it can affect the soil, and it also contaminates groundwater. It impacts water availability since aquifers (underground layers of rock that hold water) hold 97% of the earth's liquid freshwater. It can also pollute other bodies of water; one way is through groundwater since it eventually ends up in the ocean. The other way of contaminating bodies of water is through polluted rainfall. The other way of polluting bodies of water is through littering. To put it into perspective, 10 million tonnes of plastic enter the oceans each year. It can also contribute to Air Pollution and Climate Change when releasing several harmful pollutants into the atmosphere, principally when performing waste incineration. These listed consequences of bad waste management affect all living organisms ("6 Negative Effects of Improper Waste Management", 2019).

The main concept behind this poster is to display the problem by exhibiting the amount of trash produced worldwide. While simultaneously showing that most of it still ends up not being recycled or composted, i.e., it ends up in landfills, open dumps, incinerated, or in the ocean. In the same way, the Water Pollution poster (see subsection 4.2.6) is a metaphor for the ocean; this poster is a metaphor for a landfill/open dump. This poster shows the type of trash most consumed while simultaneously demonstrating the amount of time each type (of trash) takes to decompose.

For the implementation, we followed the same iterations used in the Water Pollution poster. We started by creating an array (list) and populating it with every type of trash and its amounts. The list of waste's types is the following: Paper/Cardboard; Glass; Metal; Plastic; Yard

Glass; Metal; Plastic; Yard Trimmings; Food (Organic waste); Wood; Rubber; Textile, and others (for example: electronic waste such as batteries) (EPA, 2018). We used the graphic below and its percentages as reference (Figure 4.2.6.3).

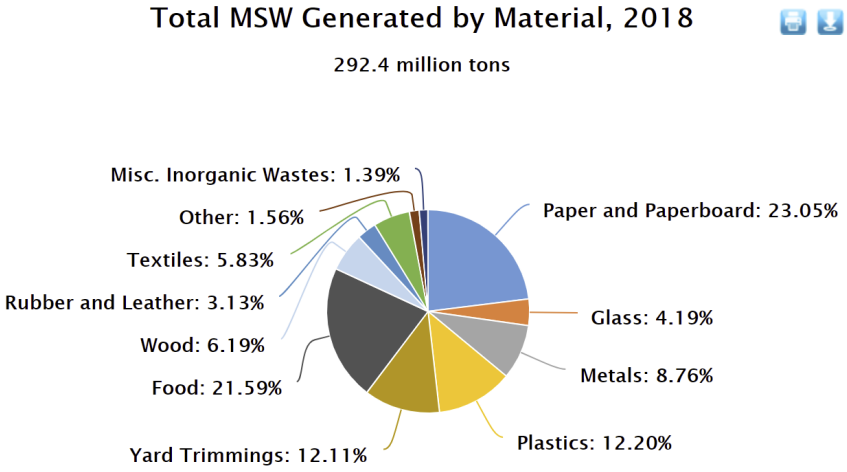


Figure 4.2.6.3
Type of waste percentage (2018)
Available at https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials

We resorted once again to the Pool Selection code used in the Water Pollution poster. It was used every 10 seconds to select and drop one item of the array based on its probability. We created an array of images for each type of trash, and each time that item is selected, we randomly choose one of the images in the array. For example, the food item has four images, rotten apple, pepper, meat and mouldy bread. Each time the food item is selected, one of those images is selected.

We also use Matter.js to add physics to our 2D objects. Here, we did not disable gravity like in the Water Pollution poster since we wanted the objects to fall from above, to look like they were being released into a landfill. Additionally, it was added a ground platform and walls (left and right side of the poster), a set of static objects that the bodies bounce off, not letting them fall out of the poster, so it will eventually fill as a garbage container.

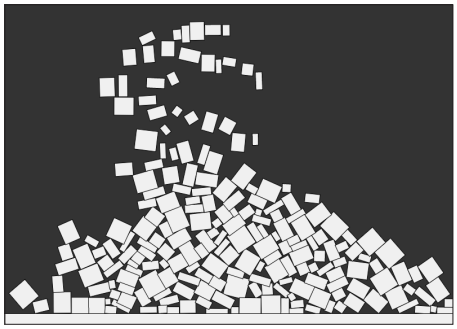


Figure 4.2.6.4
Experimentation with Matter.js physics

To decompose the items (make them disappear), we used the same concept of the Water Pollution poster. We retrieve the decomposition time (in years) of each trash item, so the glass has a value of 1 million since that is the time it takes to decompose. Food has a value of 0.5 since it can take half a year to decompose. Then, we used the same logarithmic function (log 10) to map those values into seconds. To conclude, we remove 1 second out of decomposition time iteratively until it reaches zero. Once that happens, we remove that specific item from the array and the Matter.js world.

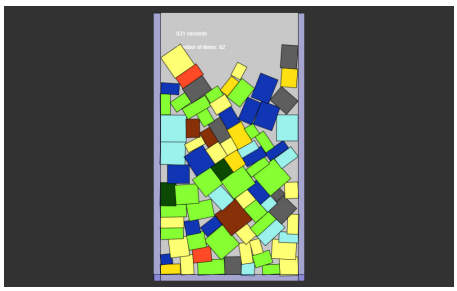


Figure 4.2.6.5
Experimentation with Matter.js physics

For the user interaction, we used the already implemented pose detection code adapted from Daniel Shiffman (see Water Pollution subsection (4.2.3)). Once a person is detected, we launch 40 (parametric value) trash items into the poster. We also displayed a message where we confronted the user by mentioning the average amount (0.74kg) of trash it discards daily. The trash produced per person can vary depending on multiple factors, the most impactful ones, the country they live in, and their income. Although waste generated per person daily

averages 0.74 kilograms, the range varies from 0.11 to 4.54 kilograms, being the high-income countries responsible for a more considerable amount of waste produced (Silpa, Yao, Bhada-Tata & Woerden, 2019).

For feedback of posters to viewers, we decided to do something different from the Water Pollution Poster instead of simply displaying the video camera in the background with some opacity. We decided to track and display the user's face inside the letter 'O' of the word 'You' in the message (Figure 4.2.6.6). To reinforce the idea that waste and its consequences are anthropogenic, the user as a human is part of the problem. To accomplish this in real-time, while the user is moving, we need to change the translation and scale parameters constantly. We implemented this through a set of defined geometrical transformations: a translation and a scale. The two variables we need to attain to perform the translation are the centre and the width of the user's face. After retrieving both in real-time, in each iteration of the poster (draw function), we calculate the X and Y distance between the centre of the letter' O' and the centre of the user's face. We translate the video image using the inverted X and Y distance. To match (the coordinates) the centre of both (face and letter 'O'). We also restricted the size of the face to the width of the circle (letter 'o'). To accomplish that, we divide the current face width by the circle width, then divide 1. For example, if the face width is twice as large as the circle, the variable value will be 0.5, using that value to operate a scale transformation to divide the video image in half. To finalize, we created a mask to restrict the video to the inside of the letter 'O'.

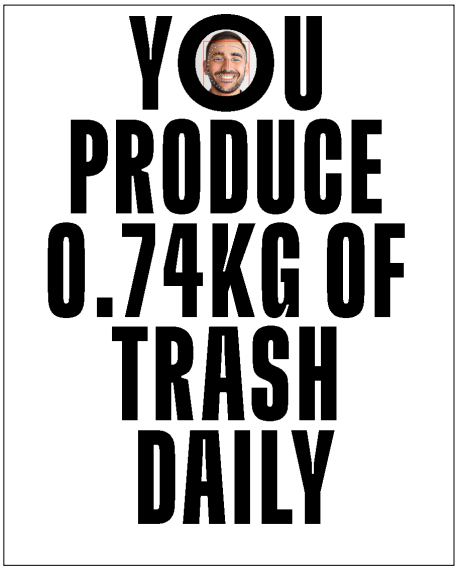


Figure 4.2.6.6
Mockup of the camera interactive effect

Summing up the animation and interaction in the poster, when a person's face is detected, the message and the user's face will appear, tracking it in real-time and placing it inside the letter 'O'. Immediately after appearing, we increase the opacity of these elements, making them fade away (disappear), behaving like an informational pop-up.

The interactive version of this poster may be accessed in <student.dei.uc.pt/~rgoncalves/PosterA/>. Also, an animated version of the poster can be visualised in <youtu.be/EstrimfVm68>. Figure 4.2.6.7 and 4.2.6.8 on the next page display the static versions of this poster.

Figure 4.2.6.7
First iteration of the Waste poster

Figure 4.2.6.7
Final version of the Waste poster

4.2.7 Biodiversity Loss Poster

As the name implies, Biodiversity refers to the variety of living species on Earth or in a specific ecosystem. Everywhere on the planet, species depend on one another to survive and evolve.

Healthy ecosystems are essential to our lives and Earth's well-being since they provide clean and filtered water, purify our air, maintain and regenerate our soil's minerals and organic matter, regulate the climate (prevent extreme heat and natural disasters), recycle nutrients and provide food for us. Biodiversity also helps us improve and find new medicines. Nearly 75% of all approved medical drugs come from nature or are derived therefrom, being plants and microbial organisms (like bacteria) the most used and studied. Since, to date, only a fraction of these living organisms have been studied, there is an unknown medical potential (Marselle, 2021; Wilson & Bernstein, 2021).

While species extinctions are something natural as we have observed throughout history, like the "Five Mass Extinctions", where more than 75% of all species at the time disappeared, it is estimated the current extinction rate is 100 to 1000 times higher than its natural rate due to anthropogenic reasons. Some studies point out we are facing the sixth mass extinction (Ritchie & Roser, 2017; "Sixth Mass Extinction of Wildlife Accelerating", 2021).

All the environmental problems we previously mentioned directly or indirectly endanger living organisms. Several human activities are jeopardising Biodiversity and, consequently, the ecosystem's health. Deforestation destroys forest habitats, water pollution (littering, contamination and ocean acidification) impacts water habitats, global warming melting polar habitats, air Pollution, population growth and its needs, and overhunting (Wilson & Bernstein, 2021).

The concept for this poster was to create an ecosystem using a set of particles, where we would display all the types of living organisms and make them slowly disappear until they are all extinct. Our intended idea was to demonstrate the vulnerability of species and Biodiversity while simultaneously showing once again that humans, through multiple activities, negatively enhance and accelerate this environmental problem.

The primary visual reference for this poster was a visual identity project for Archdiploma (Figure), created by the Design Studio Process. This project particularly caught our attention because of the Dynamic Particle System that they parametrised and manipulated to create infinite versions of it (process.studio/works/archdiploma/).

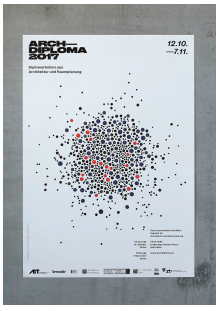


Figure 4.2.7.1
Static poster for the Archdiploma visual identity (1/3)
Available at https://process.studio/works/archdiploma/

Figure 4.2.7.2
Static poster for the Archdiploma visual identity (2/3)
Available at https://process.studio/works/archdiploma/

Figure 4.2.7.3
Static poster for the Archdiploma visual identity (3/3)
Available at https://process.studio/works/archdiploma/

We started the implementation by creating an array of objects and populating it with the different species categories and their number. The information we used was retrieved from the International Union for Conservation of Nature (IUCN) Red List (iucnredlist.org/), which summarises the numbers of species by taxonomic group. The list comprises insects, plants, fungi, arachnids, molluscs, crustaceans, fishes, reptiles, birds, amphibians, mammals, and corals ("IUCN Red List", 2021).

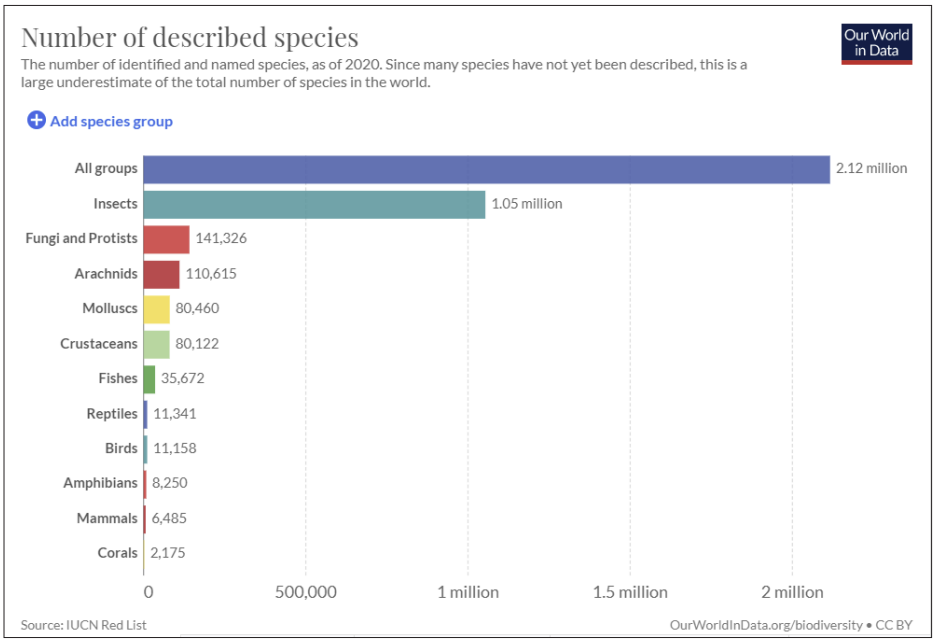


Figure 4.2.7.4
Species Taxonomy graph
Available at https://ourworldindata.org/biodiversity-and-wildlife

In the first version of the poster, we tried to achieve something similar to our visual reference mentioned above, that is, create a particle system with an attractor (particles pulled towards it). We also used colour to distinguish between species categories. For example, orange represented mammals and blue represented fishes.

With the help of Matter.js, we created and added each particle (circle object) at a random position in the poster. While the Water Pollution as Waste posters start empty, this one starts populated. To display each species category by its amount, we decided to calculate the percentage of each one in the total amount (of species). For example, there are a total of ~2.117.421 species studied (according to the IUCN Red List), amphibians have a total of 8.309, which means amphibians represent less than 1% (approximately 0.39%) of the total amount. Then, we multiplied those values by the intended number of particles (we used 100), ensuring each category (such as reptiles, birds, amphibians, mammals and corals) that represented less than 1 per cent of the total amount had at least one particle displayed ("IUCN Red List", 2021). The Figure 4.2.7.5 represented this stage of the implementation, where we started by testing the Pool Selection.

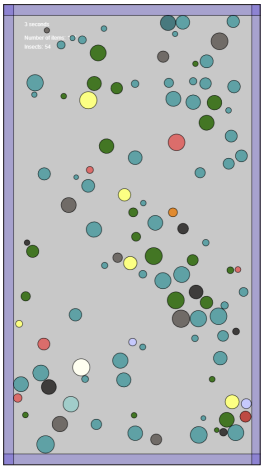


Figure 4.2.7.5
Pool Selection testing

For the attractor implementation, we used the bodies coordinates on the canvas and vectors to attract them. In the first iteration, we created a moving attractor using the coordinates of the mouse. To achieve the appearance observed in the reference mentioned above, where the

particle system had a circular gap in the centre, we created a matter.js body that followed the mouse position. For the attractor, each time the program runs, we create a vector using the distance between circle coordinates and mouse coordinates, then we divide that vector into as many segments as we choose. The higher the number, the slower the pulling force will be. Then, we add that vector segment to the particle position, smoothly following the mouse position. Since we did not intend to use the keyboard and mouse inputs in any of the posters, we changed the attractor coordinates to a static position, the centre of the canvas. In a nutshell, we place the particles at a random location in the poster, and since we have an attractor (in the middle of the poster), all particles will be pulled onto it. In the Figure 4.2.7.6 , we demonstrate the first time we were able to implement the attractor in the middle.

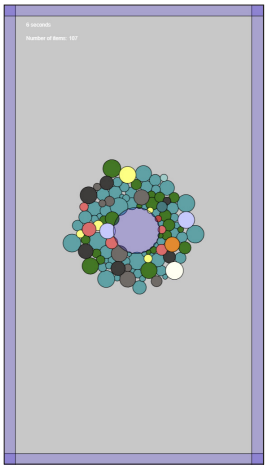


Figure 4.2.7.6
Particles being attracted to the centre (attractor)

The species “extinct” (i.e. disappearing from the canvas) was probably the most challenging part of the development of this poster. We consulted the IUCN Red List to retrieve the extinction numbers by taxonomy group. Since most values presented have insufficient coverage, the percentage of endangered species per category used on the poster can be far off what they are in reality. Since the poster’s objective is not to present detailed information but to convey a message, we think the uncertainty in these values does not affect the effectiveness of the message.

We started by dividing the total number of species in each category by the number of endangered species to obtain the probability of the species in that category getting extinct. We used these recently grasped values in the Pool Selection. However, instead of using a random number between zero and one, as we used in previous posters, we used a random number between zero and the sum of all the probabilities. Every ten seconds, we call the Pool Selection function to choose a species group. Once it is selected, we iterate through the particles array (100 elements) until we find an item with that category, then we remove it from the array and the Matter.js World.

The Pool Selection function does not know when a category has no particle; it can not choose a species group that does not exist in the poster. To solve that, we created another array and populated it with all categories and their probability. We also check the number of items in each one in real-time. When the number of particles is zero, we remove that category from the array, and the Pool Selection function does not take it into account anymore. Once that array is empty, we can presume all particles/species disappeared, and the poster is empty.

After having the particles implemented, we decided they should be represented by images instead of simply adding colour to them, since the only way for the user to know which colour represented which species category would be by adding a subtitle, transforming the poster into an information visualisation project instead. We implemented the image selection method in the same way as in the Water Pollution and Waste poster. We created an array of images for each species category and selected one of them randomly.

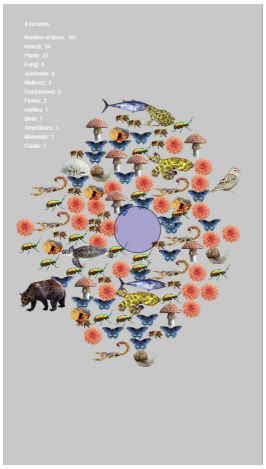


Figure 4.2.7.7
Image version of the poster

We also change the hitbox (matter.js body) to a rectangle. We made sure to research and add a few endangered species images, such as the African forest elephant, Hawksbill turtle, Atlantic puffin, corals and Bluefin tuna (World Wild Fund for Nature, n.d.).

The viewers' direct interaction with this poster is based on two methods. In the first method, the poster's system used the pose detection code used on the previous posters. To keep the cohesion between all posters, we also decided to add a message when a person is detected. We display an estimated number of endangered species (over 34 480), retrieved through an IUCN article. While that number (34 480) seems substantial, it is most likely a significant underestimate of the total number of species at risk since they (IUCN) did not check every single species known and are still a considerable amount of species to be found and studied.

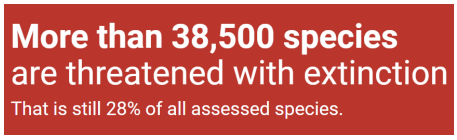


Figure 4.2.7.4
Number of species in risk of extinction by IUCN Red List
Available at https://www.iucnredlist.org/

On the other hand, the other interactive part was to create a single iconographic image that represents humans on the poster. Since we are jeopardising species and accelerating biodiversity loss through various activities (that destroy and disrupt ecosystems), it makes sense that particles (i.e. the animals) deviate from the viewer's location (centre of the human face). We accomplish that by adding another attractor, but this one with a stronger force than the centre attractor. So when a human appears (is detected), we create a vector between the particles coordinates and the user coordinates (centre of the face), but instead of making the particles follow it by adding a segment of the vector, we invert the coordinates (of the vector), making the items move in the opposite direction, giving the perception that they are running away from the human ("Biodiversity", 2019).

Also, to further demonstrate that humans cause and accelerate this problem, instead of removing one species each ten seconds, we cut that time to half (five seconds). When all the particles disappear, or in other words, all species have been extinct, we repopulate all the empty arrays and display all the images again, returning the poster to its initial state.

The interactive version of this poster may be accessed in <student.dei.uc.pt/~rgoncalves/PosterC/>. Also, an animated version of the poster can be visualised in <https://youtu.be/upxQSdpOCh0>. Figure 4.22 and 4.23 on the next page displays the static version of this poster.


OVER 34,480
SPECIES ARE
THREATENED
WITH
EXTINCTION
Metamorphosis: Experiments in the Design of Interactive Moving Posters
Full Exhibition at metamorphosis.dei.uc.pt

Figure 4.2.7.5


OVER 34,480
SPECIES ARE
THREATENED
WITH
EXTINTION
Metamorphosis: Experiments in the Design of Interactive Moving Posters
Full Exhibition at metamorphosis.dei.uc.pt

Figure 4.2.7.6

4.3. Exhibition

We designed and developed a website to present the developed work in an online-based exhibition. The focus of this exhibition is the poster, so we aim to design something visually clean and simple to navigate. This way, we display the seven static versions of the posters on a responsive grid on the website. When the static version of a poster is clicked, we redirect the user to another webpage that has the full animated and interactive version of the poster. We also created an About button to display particular information related to the project, such as its title, project description, goal and context, Authors, Libraries used and images links. Also, we designed a visual identity for the exhibition based on the letter 'M' on the same typeface used on posters developed (Figure 4.3.1). The website elements (e.g. loading animations, typeface styles, etc.) are designed based on this installation. Figure 4.3.3 presents a screenshot of the website. Figure 4.3.2 presents a screenshot of the loading screen. The Figure 4.3.4 presents the About content. The online exhibition is accessible in the following URL: (student.dei.uc.pt/~rgoncalves/Website/).

Furthermore, we also aim to create a physical exhibition of this work; however, due to the current pandemic restrictions, we cannot ensure the safety of the exhibition viewers. In this sense, until nowadays, this work is only presented online.

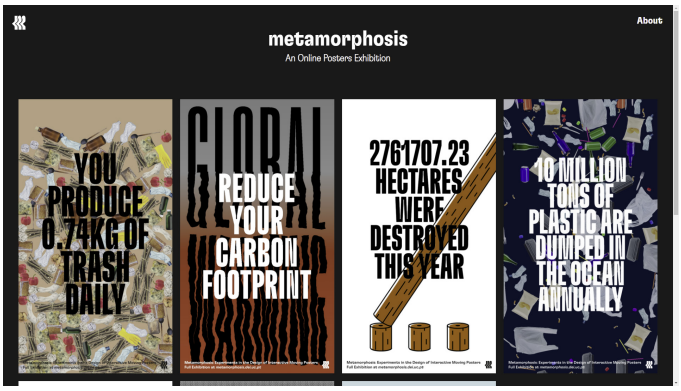


Figure 4.3.3
Exhibition loading screen

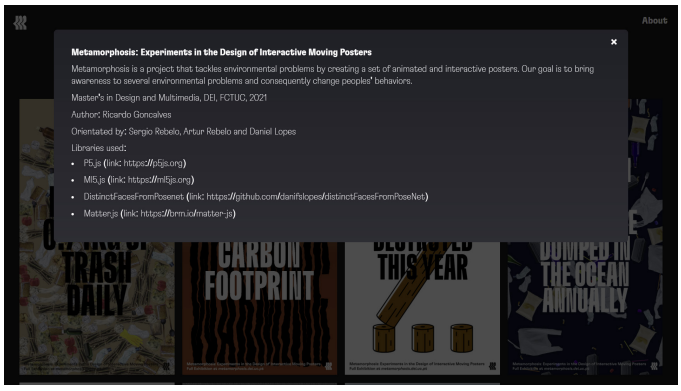


Figure 4.3.4
Exhibition loading screen

Figure 4.3.2
Exhibition loading screen

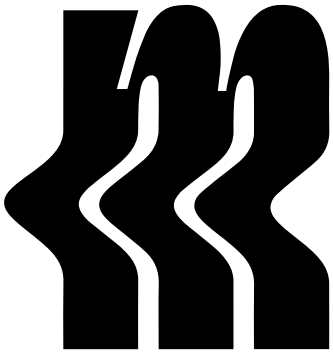


Figure 4.3.1
Exhibition/ Project Logo

5. Evaluation

5. Evaluation

While we intended to evaluate each iteration of the posters as recurrently as possible, with users in a physical environment. Due to the COVID-19 restrictions, we had to adapt and test the project through a web-based form. Our goal for the testing sessions was to evaluate the posters as a whole and individually. We also added Google Analytics to our website and posters to examine which poster people spent more and less time seeing/ interacting with (Figure 5.1 and 5.2).

Figure 5.1.
Number of user and their average interaction time

PAÍS	UTILIZADORES
Portugal	26
United States	6
Netherlands	3
China	1
Germany	1
Philippines	1
Serbia	1

Figure 5.2.
Users access country

We evaluated the project in two different times and, consequently, we created two form versions, one in mid-August and the other in mid-September. We used the collected responses from the first version to improve upon the problems found. Most of them were minor problems related to posters' content and performance. The found issues related to the content are the following: (i) a typo in the Biodiversity Loss poster message; and (ii) the subtitle in the Noise Pollution not being visible. On the other hand, the biggest identified problems were related to performance and accessibility of posters since some users could not explore the interactive version of the poster. To solve the accessibility problem, we decided to add a loading screen, followed by a window with a set of instructions.

When creating the final survey, we reviewed the questions of the first form, removing some unnecessary questions and adding some pertinent ones. We made sure to include quantitative (multi-choice Likert scale questions) and qualitative (open-ended questions) evaluations to retrieve the feedback as diverse as possible. The form was created using the Google Forms software.

The first section simply asks the tester its age and if it has some sort of design background. The questions were:

1. Age?

2. Do you have any Graphic Design or Visual Communication background?

In the second section, we tried to evaluate the set of posters as a whole (its cohesion) and understand which of the posters testers found least and most visually appealing. For a visual guide, we placed an image with the seven posters aligned.

3. Do the posters in the exhibition look visually cohesive?

4. Please, order the posters below from the least visually appealing to the most visually appealing? Please, judge them from the website and use the image below only as a reference.

In the **third section**, we evaluate each poster and its three versions (static, animated and interactive). We wanted to find out if the tester understood the main environmental problem we were conveying and which of the three poster versions were the most and least effective. We published an image of the static version of each poster, a Youtube video with the animated version and a link to access and explore the web-based interactive version.

5. Were you able to access the interactive version?

6. How attractive does this poster look? (**You may take into consideration the posters' appearance, dynamism and interactive features**)

7. Why?

8. What is the environmental issue that this poster is related to?

9. In your opinion, what version of this poster transmits the message in a more efficient way?

10. Why?

11. Would you change anything to improve the effectiveness of the poster?

We used the fourth and final section to understand if the overall techniques used (interactivity) helped transmit the message or if the static version still prevails as the best way of creating and displaying a poster.

12. In comparison to the STATIC poster, do you think the ANIMATED one helped in the comprehension of the message? Or the other way around?

13. Why?

14- In comparison to the ANIMATED poster, do you think the INTERACTIVE one helped in the comprehension of the message? Or the other way around?

15. Why?

16. From the static, animated and interactive approaches, which one do you think will stand the most in people's memory?

17. Feel free to leave further comments and suggestions.

Collecting feedback and analyzing the results

The biggest challenge for us was to get some pre-disposed testers. Due to the large size of our questionnaire, most people would enter the form and not answer it. We observed through Google Analytics. The number of people who interacted with our posters/website was significantly higher compared to the actual number of answers received.

Not only did we share it with a few friends and colleagues, but we also posted the questionnaire on Reddit, specifically, on the r/creative, r/typography, r/graphic_design, r/Design, and r/SampleSize subreddits. Despite combining a lot of traction (over 2000 views), no one filled our questionnaire (Figure 5.3).

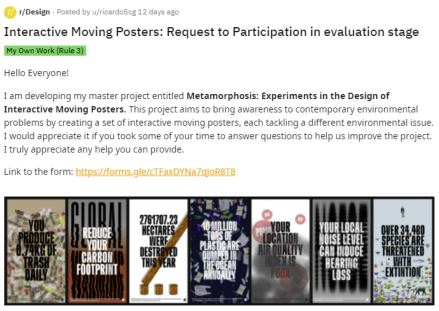


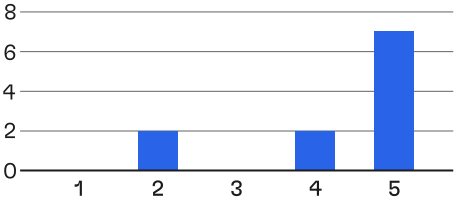
Figure 5.3.
Post in the Design subreddit

Despite that, we ended up receiving thirteen answers. From those thirteen answers, we deleted two of them since those two testers said they could not interact with any of the posters, making their feedback less valuable since they could not choose between the three versions of posters (static, animated and interactive).

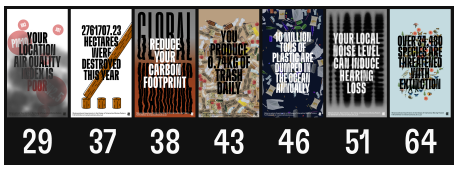
From the eleven answers, we analyzed seven of them by designers and four by non-designers. The age gap was between 22 and 30, and the mean age of the testers was ~25.4 years old.

Our goal for the **second section** of the questionnaire was to retrieve basic information about the posters as a group.

1. Do the posters in the exhibition look visually cohesive?
The answers were positive since the majority chose the maximum answer of five. The Evaluators answered this question with a ~3.91 mean. The results increased slightly compared to the first evaluation form, considering we added a message to each poster, increasing its cohesion.



2. Please, order the posters below from the least visually appealing to the most visually appealing?
For this question, we asked the testers to order the posters from least to most visually appealing (one to seven). To grasp the answers, we attributed a point to the least and seven to the most appealing. That is, the poster with the most points was considered most appealing and vice versa. The posters that stood out as more appealing were Biodiversity Loss (64), followed by Noise Pollution (51). The least appealing poster was Air Pollution (29).

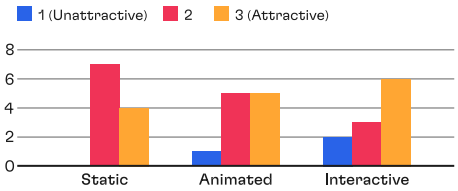


For the **third section** (individual poster evaluation), we created Linkert scale questions, followed by open-ended ones to understand the tester's decisions.

Waste poster evaluation:

1. Were you able to access the interactive version?
Everyone answered 'Yes' to this first question.

2. How attractive does this poster look?
Despite the results being diverse, the three versions had similar attractiveness ratings.



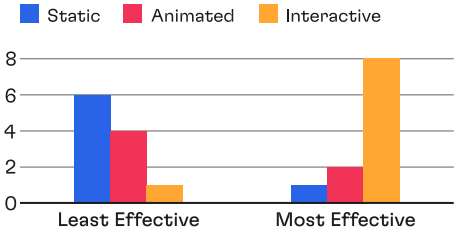
3. Why?
This question was utilized to understand the answers chosen above. The opinions vary from tester to tester. It either likes the interaction (face inside the letter 'O') or dislikes it and finds it somewhat uninteresting. This is the reason for us to include open-ended questions to support the Likert scale ones. To demonstrate, we will place two distinct answers below:

"The static poster just gives you the idea of the problem, the animated poster is more captivating, but the best one is the interactive one, by including our faces into it, it really makes it personal and puts yourself in "the spotlight" so to speak." – Tester #9

"I really like the animation of the trash falling, however I don't like the camera capture in the the 'O' character." – Tester #10

4. What is the environmental issue that this poster is related to?
Every tester understood that the message was related to Waste. Some of the answers were "Waste", "Urban Waste", "Trash", and "Trash that a person makes per day".

5. In your opinion, what version of this poster transmits the message in a more efficient way?
While the answers vary from person to person, we can definitely recognize that the interactive version was the most effective out of the three, receiving eight out of the eleven answers.



6. Why?
Some of the reasons for the interactive version being the most effective were that the 'You' camera effect really sells the idea that the human is the one to blame. Another reason was that the interactivity creates a personal connection with the user, making it rethink his actions and the trash he produces. Another tester disagreed with the points stated above; while still writing some interesting feedback. It stated the static version was the most efficient since it instantly displays a large amount of trash (poster filled), and the 'You' camera effect was somewhat 'gimmicky'.

7. Would you change anything to improve the effectiveness of the poster?
This question helped us retrieve some interesting feedback. Two of the answers suggested adding more trash (e.g. tissues, cans, food leftovers, etc.) but keeping the colour scheme. The other was to decrease the size of the elements gradually; this would be interesting to implement, especially for an outdoor installation, where people interacted with it all day, this way, taking longer to overfill the poster. Another suggestion was to increase the number of elements dropping in each interaction, creating a more impactful message.

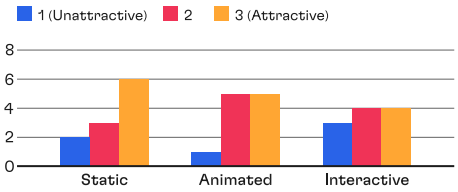
Global Warming poster evaluation:

1. Were you able to access the interactive version?

Three people (27.3%) out of eleven said they could not access the interactive version. There could be different reasons for this. One is that the interactivity in this one is subtle, making the tester not realize it already happened and think it is not working. Another issue can be the fact that the tester did not close the other poster, not letting this one access the webcam; thus, the interaction not working. With posters that had some users unable to access the interactive version, we need to analyze the results with caution since they can be somewhat misleading.

2. How attractive does this poster look?

Once again, the answers to this question deviate from tester to tester. We can perceive that testers found the static and animated version slightly more attractive than the interactive one.



3. Why?

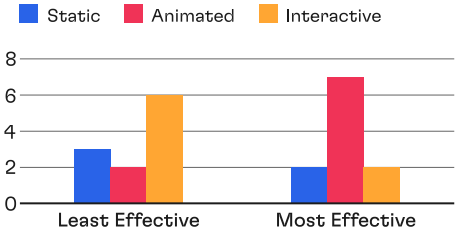
Most testers used this question to express that the colours and texture/distortion was well perceived as heat.

4. What is the environmental issue that this poster relates to?

Since the title of the environmental problem is present in the poster message, everyone could quickly identify it.

5. In your opinion, what version of this poster transmits the message in a more efficient way?

This time, we see the animated version (seven answers out of twelve) being perceived as the most effective version of transmitting the message. In contrast, the interactive was perceived as the least effective. One took the opportunity to mention that the interaction does not add much to the transmission of the message while also mentioning the reason he chose the animated as the most appealing and effective.



"I think there was something wrong in the interactive version, as the only thing it did was show the Reduce your carbon footprint...About the other two versions, I really like this animated version, as the effect really gives a feeling of heat and incoming doom that the static one simply cannot convey." – Tester #8

6. Why?

Some users used this question to write that it is not perceptible how the interactivity reflects the problem and improves the message in any way.

7. Would you change anything to improve the effectiveness of this poster?

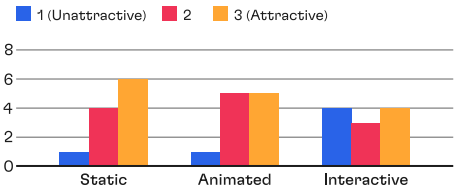
The feedback received in this question was mainly aesthetic. One tester suggested changing the colour to blue, which evokes the ocean tone. One tester suggested decreasing the intensity of the texture/effect to improve visibility, while another suggested the exact opposite (increase the effect intensity) to cause more impact.

5. Evaluation

Deforestation poster evaluation:

1. Were you able to access the interactive version?
This time, two (18.2%) out of eleven people could not access the interactive version.

2. How attractive does this poster look?
The testers perceived the static as the most attractive version, opposed to the animated and interacted ones.



3. Why?
With this question, we could understand the reason interactivity got lower ratings on the previous question. Several testers did not understand that their (human) presence made the trees fall, and their absence made them grow back.

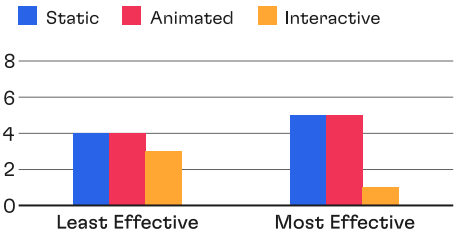
"In the interactive poster can't see the final message as the tree starts growing right after being cut, so it's just a cut and grow loop." – Tester #2

This answer shows that the tester did not understand the interaction. What most likely happened during the test was, the algorithm stopped recognizing him right before the smoke and message appeared, making the trees regrow back into their original state. The user thought there was no interaction, and the poster was a simple animated loop.

In the future, we can prevent these, or at least, happen less frequently by increasing the performance/speed of the poster. In other words, once a person is detected, the trees should almost instantly be cut so that the user can more easily understand the interactivity.

4. What is the environmental issue that this poster relates to?
Everyone understood the poster' environmental problem as being Deforestation.

5. In your opinion, what version of this poster transmits the message in a more efficient way?
Almost every tester chose the static or the animated version to be the most and least effective.



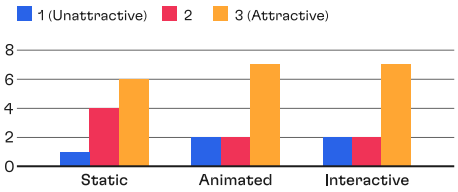
6. Why?
One tester succinctly described every poster version. It starts by saying that the static poster is simple and effective. It says the animated version (video) does not need the part where the trees grow back since they do the opposite of displaying the problem. It also comments that the interactive version should be "more responsive"; in other words, once a user enters the webcam range, it should immediately start the cutting trees animations. This lack of optimization was one of the factors for the interactive version not being selected by many.

7. Would you change anything to improve the effectiveness of the poster?
Some visual feedback received suggested adding a bark texture to the trees, removing the illustrated look they have, giving more coherence since the other posters use real images and not illustration. An opposing suggestion was to change the appearance of the smoke for a cartoon (illustrated) look. Others suggested making the interaction between the user and the poster clearer. For it to react more evidently and faster to the user's presence while suggesting it could require the addition of more trees to the composition.

Water Pollution poster evaluation:

1. Were you able to access the interactive version?
This time, one (9.1%) out of eleven people could not access the interactive version.

2. How attractive does this poster look?
For the first time in this evaluation, we observed every poster version receiving more number three (maximum attractiveness) ratings above the two and one (unattractive) ratings.



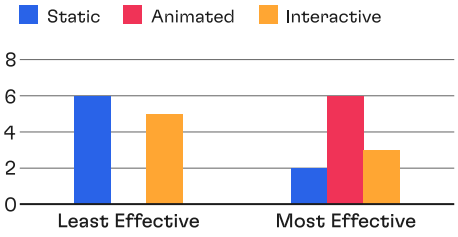
3. Why?
Some of the answers received sustained the results obtained in the previews answer. Some examples are:

"I found all versions quite nice." – Tester #8

"Very nice aesthetic, they all are very effective at communicating the problem." – Tester #10

4. What is the environmental issue that this poster is related to?
Everyone understood the environmental problems displayed on the poster. Most said Water/Marine/Ocean pollution, while three testers mentioned plastic in the ocean, which is not incorrect per se since most elements found in the ocean are plastic. However, we also include paper and glass items.

5. In your opinion, what version of this poster transmits the message in a more efficient way?
Surprisingly enough, the interactive version was not chosen as the most efficient by the users, getting fewer selections than the animated version.



6. Why?
The answers brought a lot of valuable feedback, both supporting the animated and interactive versions as the most effective. Some testers did not choose the interactive version because, by displaying the camera input on the poster, we blame the individual for this massive problem, making the user adopt a defensive position while interacting with the poster.

Most trash thrown in the ocean is “due to industrial activities, illegal dumping by corporations, and inadequate waste disposal management by governments”. They finish saying we should have personal accountability and do our part to keep the ocean clean. Individuals should not be blamed for this increasing problem.

On the other side of the spectrum, two testers explained why they chose the interactive as most effective. They focus their reason on the camera input present, making the user “feel much more guilty and self-conscious of the problem”. The other element was the part where the user could try and push/move trash out of the poster, demonstrating it is much easier not to dump it into the ocean than to clean them.

7. Would you change anything to improve the effectiveness of the poster?
One tester suggested increasing the rate at which trash spawns, and when the poster is filled with trash, “spam” (quickly showing and hiding) the text to increase the impact and overwhelm the viewer.
Another user suggestion described what occurs in this poster. Either it could not access the interactive version and see for himself, or it did not wait long enough to see the poster get filled with trash. The suggestion was:

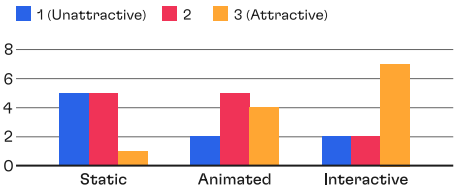
“... I think the interactive could be more interesting for example if the user had to pick up the trash in the ocean... And as the time passes it would increase the amount of trash to a point the user cannot handle it to show the impact of the huge amount of trash that goes to the ocean that only one person is not capable of cleaning it but it has to be a cooperation between all of us”.

Interesting suggestion since we made sure to add an object for each person detected, so we can have multiple users simultaneously interacting with our communication artefact.

Air Pollution poster evaluation:

1. Were you able to access the interactive version?
Two users (18.2%) out of eleven people could not access the interactive version.

2. How attractive does this poster look?
We can observe an order between them: the static poster classified as the least attractive (with only one ‘attractive’ rating) and the interactive as the most attractive, with seven ′attractive′ ratings.

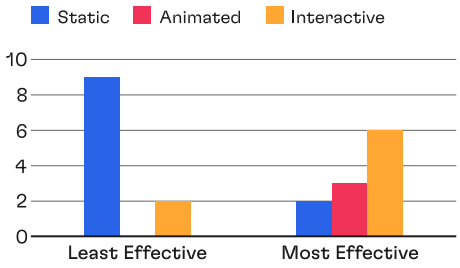


3. Why?
The summarized several users answered they were not the biggest fans of the static version. However, the animated and interactive versions brought the poster to life with the animated smoke and particles.
Two users took the opportunity to give some suggestions.

One pointed that the circles were too flat, and we should give them some sort of texture. It also pointed that the text inside the circles was not perceptible as air pollutants designation. Another user suggested the poster having the location name instead of the text “Your Location”.

4. What is the environmental issue that this poster is related to?
Once again, we are delighted to know everyone could identify the problem in question. Everyone wrote either Air pollution or Air quality, while one user went to the extent to write “The decline in air quality due to pollution”.

5. In your opinion, what version of this poster transmits the message in a more efficient way?
With these answers, we can calculate that the interactive version was, by a slim margin, the most efficient in transmitting the message, while the static poster was undoubtedly the least.



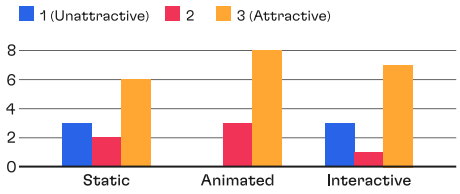
6. Why?
The interactive was the prefered version by most users because it is the only version that displays the user’s location AQI, so a frozen frame of the poster is the consequence of multiple factors, such as the user presence and AQI in a specific location and time.

7. Would you change anything to improve the effectiveness of this poster?
While almost anyone answered, one user, gave a good suggestion, it said that we could also change the text according to the AQI value; the higher the value, the fuzzier it could become. In contrast, the lower the value, the sharper the text would be.

Noise Pollution poster evaluation:

1. Were you able to access the interactive version?
Two users (18.2%) out of eleven people could not access the interactive version.

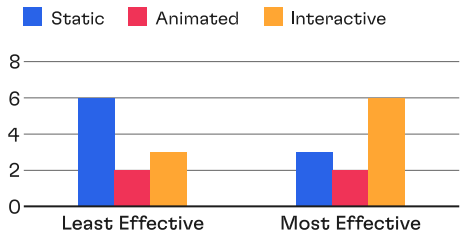
2. How attractive does this poster look?
While the animated version was the only one without an ‘unattractive’ rating, we were pleased to see that overall, every version received a positive rating, where the ‘attractive’ votes exceeded the other options.



3. Why?
Users used this open-ended question to explain the pros and cons of each version. While several testers said, the static version worked well since it expresses the message almost instantly. Others found the static less efficient since the background Noise design is not as visible. The animated version better expressed the cause/effect of the problem, being the most significant disadvantage that it does not show the message as the interactive does. The interactive shows in real-time the “dynamism between the actual sound and the effect it has on the typographic work”.

4. What is the environmental issue that this poster is related to?
Everyone could identify the environmental problem present in the poster, Noise/Sound pollution.

5. In your opinion, what version of this poster transmits the message in a more efficient way?
Reading the previews open-ended answers, we could predict this outcome of the interactive version considered the most effective.



6. Why?
The answers summary were that the interactive version was the most effective since it only reacts in real-time to the user's local environment noise. Its sound reaction made this version most engaging, and fun to view/interact with. An answer that demonstrates this is:

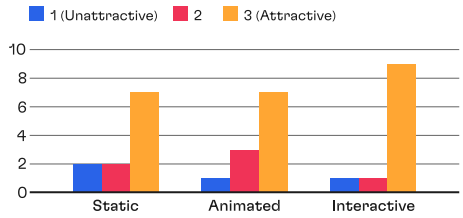
"This time again, the interactive version was fun and nice to use. And the fact that the message fades in whenever you hit a certain noise level is pretty cool, and helps deliver the poster's message." – Tester #6

7. Would you change anything to improve the effectiveness of this poster?
Most people either did not answer or answered 'no' to this question since they gave all their feedback in the previous open-ended questions.

Biodiversity Loss poster evaluation:

1. Were you able to access the interactive version?
One user (9.1%) out of eleven people could not access the interactive version.

2. How attractive does this poster look?
As we calculated in the previous section, this poster was considered the most appealing out of the group, so it came as no surprise that every version was received as attractive by the majority.



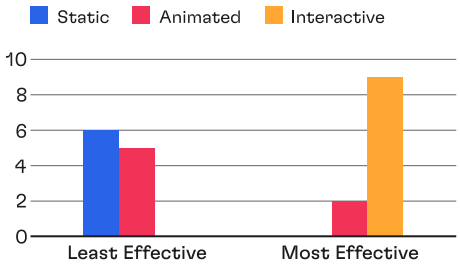
3. Why?
Most testers used this question to express that all versions visually and conceptually worked. Some answers that demonstrate this is:

"The colors, the message, the graphic elements and the metaphor work really well" – Tester #2

"They all feel balanced and work." – Tester #4

4. What is the environmental issue that this poster is related to?
While no tester used the expression "Biodiversity Loss", all correctly answered the poster theme of Animal/Species extinction. One user took his answer further and wrote, "The Holocene extinction", also referred to as the "Sixth mass extinction" and "Anthropogenic extinction".

5. In your opinion, what version of this poster transmits the message in a more efficient way?
By looking at the graph, we can definitely see that the interactive version was considered the most effective by almost everyone (nine testers out of eleven).



6. Why?
In their own experience and perception, almost every tester explained why the interactive poster is the most effective of all three versions. A good that well expresses this is:

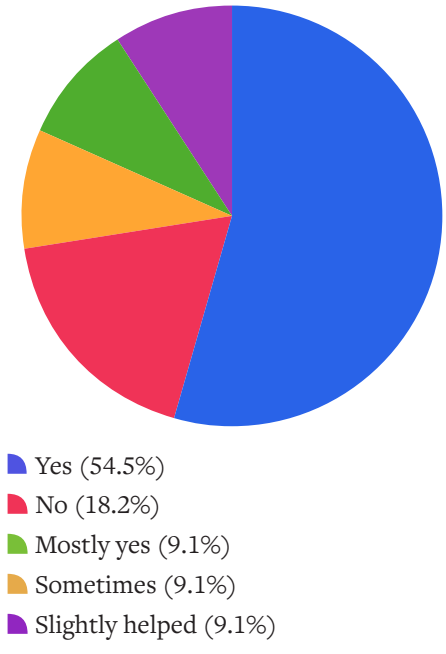
"We can clearly see what's the cause/effect. By controlling the man in the poster, we can also associate ourselves with that man, therefore, seeing how we're also responsible for this problem." – Tester #11

The way we let the user control the human position in the poster further insinuates the human involvement and its consequences, not blaming the user as an individual but blaming humans as a whole.

7. Would you change anything to improve the effectiveness of the poster?
Most users either did not answer or wrote 'no' to this question. One suggestion was to remove the species after a while, which demonstrates the user did not understand/see the species disappear. The other suggestion was to change the human image for the user camera input. While this is a good suggestion, this would make the poster run even slower while not adding much to the poster.

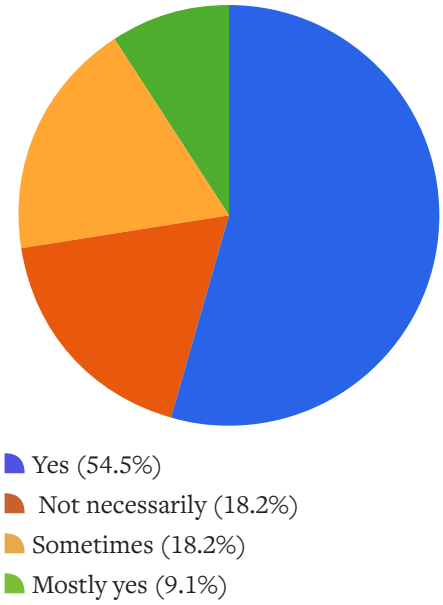
For the **fourth** and last section of the evaluation:

1. In comparison to the STATIC poster, do you think the ANIMATED one helped in the comprehension of the message? Or the other way around?
While the answered change completely from user to user, we can retrieve most (54.5%) found the animated version helped in the comprehension of the message. Only 18.2% thought the static version was superior. The other 27.3% either found the animated slightly better overall or were uncertain since (animation) only helped in the transmission of the message in some cases.



2. Why?
While some users answered, the animated versions added an extra layer of interpretation to the problem and helped establish a connection between cause and effect, transmitting the message more efficiently. Others thought the animated simply was more captivating while also saying it does not add much to the static version apart from that.

3. In comparison to the ANIMATED poster, do you think the INTERACTIVE one helped in the comprehension of the message? Or the other way around?
Once again, we can see that the majority (54.5%) thought the interactive version transmitted the message more efficiently than the animated version. Three users (27.3%) either answered that sometimes or most of the time helped. The last 18.2% were two different answers, they did not agree with the question, they explained why by saying that despite not helping with the comprehension of the message, they created a personal connection with the user, adding more value to the artefact and creating a more shocking reaction.



"It might not help to understand the message but it creates a direct connection to the user which creates a more shocking approach, which is good". – Answer #1

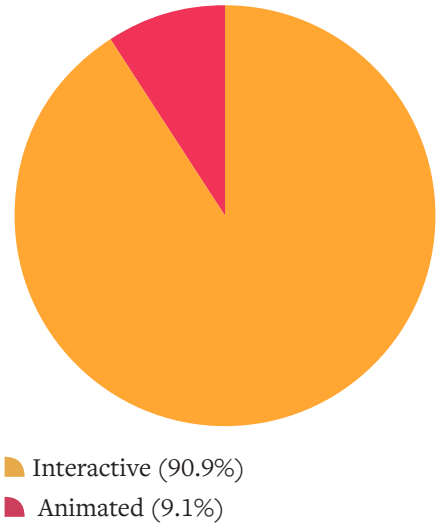
"The interactive ones didn't help the comprehension of the message per se, they just made them more attractive and more personal, adding value to the content" – Answer #2

4. Why?
Even the tester that slightly disagrees with the question above still mentioned how the interactive always added something that the other two versions could not, from the dynamism, bigger detail, and real-time information. Some answers that prove this:

"Most of the time the interaction lets the viewer take part in revealing the true meaning behind the poster and that brings some gratification. It also puts the viewer in charge of their action and see their part in those problems." – Tester #2

"Helped convey the story in a more personal way by placing the user as an integral part of the question." – Tester #9

5. From the static, animated and interactive approaches, which one do you think will stand the most in people's memory?
The results to this question were even better than expected since almost everyone (90.9%) thought the most memorable version of the posters was the interactive. The other user (9.1%) chose the animated version.



6. Feel free to leave further comments and suggestions.
One user suggested increasing the performance and optimising each poster, especially those that use the camera as an input. Another user suggested increasing the visual coherence in some posters, specifically the deforestation and air pollution posters. Others simply wrote that the posters looked great overall.

User's Evaluation conclusion

Concluding, while we did not receive as many answers as expected, most likely to the large size of the form, we still received some interesting feedback. We wanted to know if the tester quickly understood the problem we presented in each poster; this was a success since every tester identified the seven environmental issues. We wanted to receive feedback about each version of the posters and improve upon them visually or conceptually.

The other thing we wanted to understand was if this up and coming creative medium, the moving interactive poster, was superior in any way compared to the static and the animated. While we need to consider that we only received eleven answered, we can confidently say that the interactivity created a more engaging and personal connection with the user most of the time.

In the future, we would like to redo this evaluation in a physical environment, with a larger number of users, to fully understand the downsides and the advantages of interactivity in creating posters.

Evaluation graphical content

Figure 5.4.
Waste poster Mockup

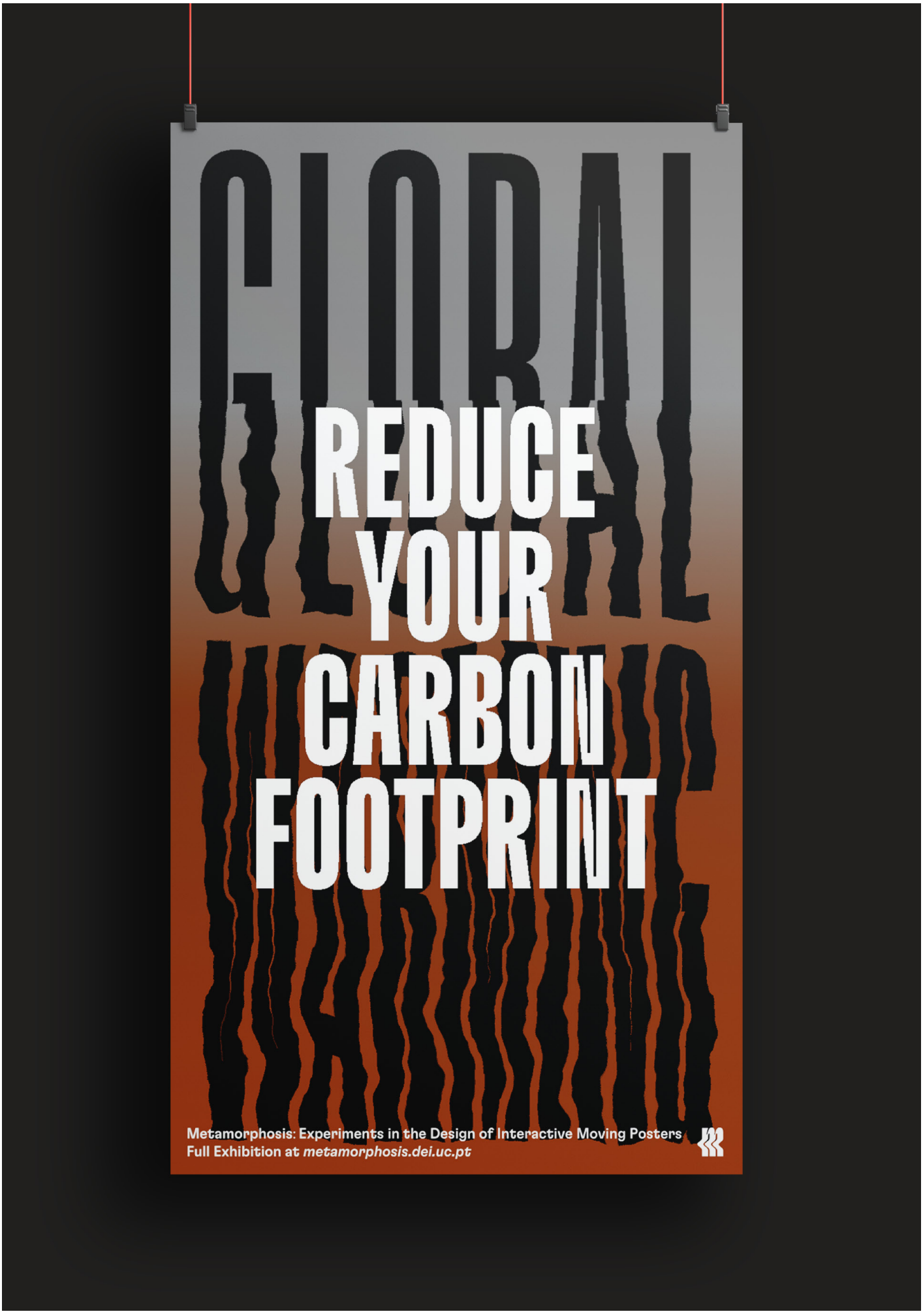


Figure 5.5.
Global Warming poster Mockup

Figure 5.6.
Deforestation poster Mockup

Figure 5.7.
Water pollution poster Mockup

Figure 5.8.
Air pollution poster Mockup

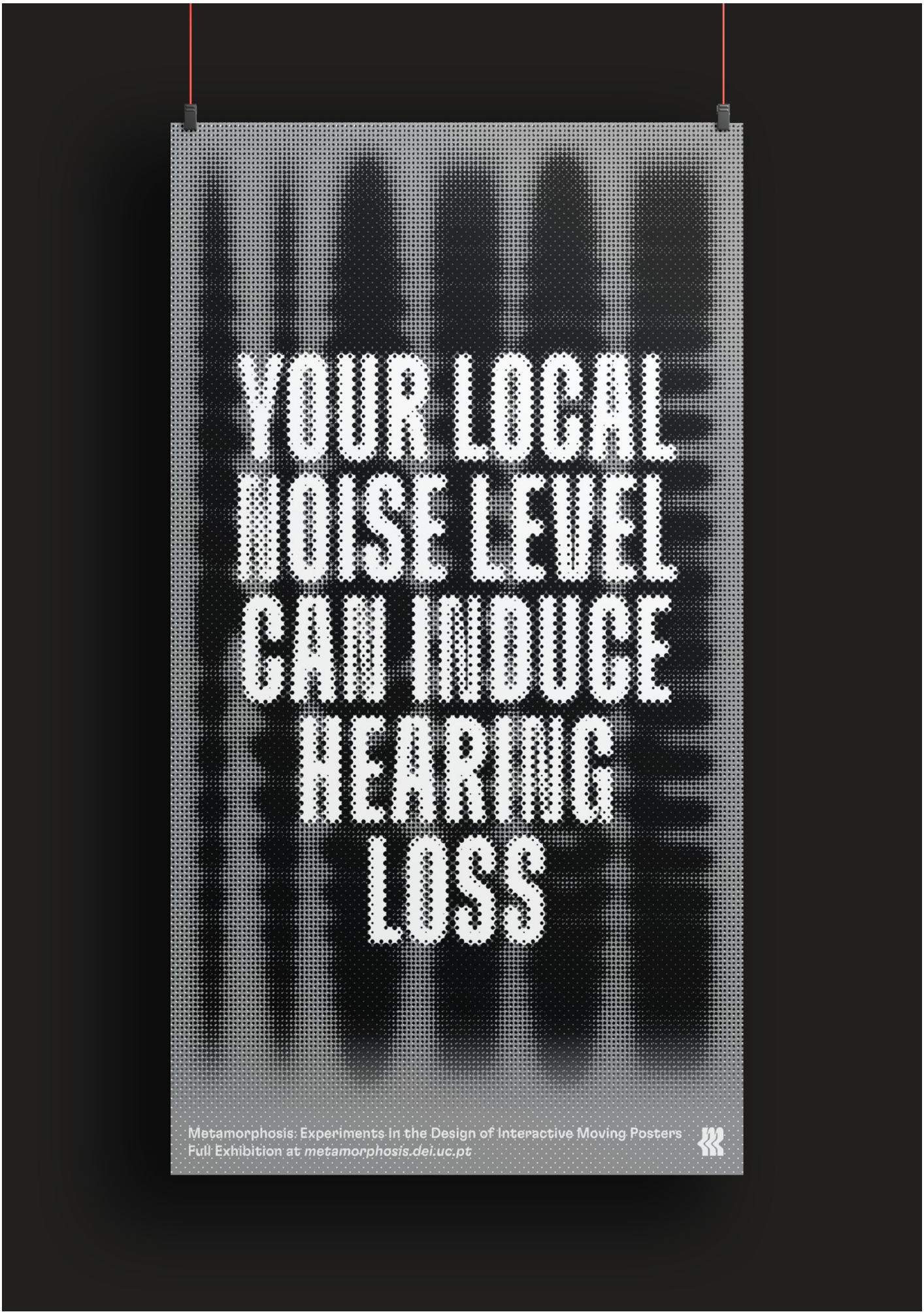


Figure 5.9.
Noise pollution poster Mockup

Figure 5.10.
Biodiversity Loss poster Mockup

6. Conclusion and Future Work

6. Conclusion and Future Work

The poster is one of the most effective ways of disseminating information. Its predecessors can be found in ancient times (Acta Diurna), and over the eras, they evolved aligned with the technological advances of the times (Meegs & Purvis, 2006; Guffey, 2014). Thus, for centuries, graphic designers have been trying to find better ways to create them and better captivate the attention of the passers-by. The advent and democratisation of the Personal Computer and creative code tools brought a lot of new creative possibilities that otherwise would be unthinkable (Sontag, 1970, Richardson, 2016). Therefore, fields of study such as Algorithms and Interactive Design affect the design processes of poster designs. In this context of this dissertation, we study and explore these technologies and methods with the primary objective of developing poster designs that employ digital-driven design approaches, such as Algorithm Design and HCI.

This way, in this dissertation, we created a set of interactive moving posters that either visually translate data gathered directly (*i.e.* reading and tracking the viewer's behaviour and the state of its surroundings) and/or indirectly (*i.e.* accessing context-aware data and data collections based on the state of its surroundings).

We presented a brief research focusing on the history and the crucial events that shaped the way posters are viewed and designed. Also, we presented some works that in some way are related to our project, whether in their use of motion, algorithms or interactive elements. The posters are designed under the theme metamorphosis, exploring how the viewers and the environmental changes may affect the value of the message transmitted and, consequently, produce different behaviours in the viewers. Thus, each poster reflects on another environmental issue (Air Pollution, Biodiversity Loss, Deforestation, Global Warming, Noise Pollution, Waste and Water Pollution). The resulting designs are displayed in an online exhibition, which is accessible at (student.dei.uc.pt/~rgoncalves/Website/).

We employed an agile and iterative methodology in the development of this work. The poster development started with multiple mock-ups of how each poster could look. Based on the evaluation of these mock-ups, we defined the visual techniques and employed techniques. Next, we developed the posters and the online website that presents them. We evaluate the created design posters individually (i.e. at poster design level) and collectively (i.e. the whole set of posters). In the evaluation session, we expect to evaluate the posters' quality qualitatively and quantitatively based on direct replies of users to a survey that includes Likert-scale and open questions. The evaluation stages are performed online. The first evaluation stage (held during mid-August) was more focused on helping us to identify performance and interface issues. In these sessions, ten people participated, and we could locate several minor problems related to posters content and performance. In the second session (held in mid-September), thirteen users answered, but we removed two since they could not access any interactive versions.

As for the results, the second user testing session was way more valuable than the first survey, principally due to the changes we made to the questions. Those pertinent questions helped us understand that most of the testers prefer the interactive version compared to the animated and the static, as well as their reasons.

We are currently working on submitting the dissemination of this work, more concretely working on an article for the Design Research Society (DRS) 2022 Conference (deadline 24th November of 2021). Also, future work on this project will be focused on: (i) physically set-up the installation and study if the transition of the message is more, or less, effective than in the online exhibition; and (ii) increasing the amount of explored environmental issues and posters.

7. Bibliography

Bibliography

Aastha, A. (2019). *Air Pollution: What Is Air Quality Index, How Is It Measured And Its Health Impact.* Retrieved August 29, 2021 from https://swachhindia.ndtv.com/air-pollution-what-is-air-quality-index-how-is-it-measured-and-its-health-impact-40387/

ACM. (2019). *Julius Caesar invented first Newspaper called "Daily News" Acta Diurna.* Retrieved January 17, 2021 from https://ancientcoins.market/julius-caesar-invented-first-newspaper-called-daily-news-acta-diurna/

Åkestam Holst. (n. d.). *Blowin' in the Wind.* Retrieved September 19, 2021, from Åkestam Holst: http://www.akestamholst.se/ourwork/blow-in-in-the-wind/

Armstrong, H. (2016). *Giving Form to The Future. Digital Design Theory: Readings From the Field.* H. Armstrong, ed. Princeton Architectural Press. 9–20.

Armstrong, H. & Stojmirovic, Z. (2011). *Participate: Designing with user-generated content.* Princeton Architectural Press.

Aurélio, M. (n.d.). *Pure CSS Halftone Effect.* Retrieved August 21, 2021 from https://codepen.io/coreh/pen/LQJBLa

Berglund, B., Lindvall, T., & Schwela, D. (1995). *Guidelines for Community Noise.* Retrieved August 20, 2021 from http://www.who.int/docstore/peh/noise/Comnoise-1.pdf

Blauvelt, A. (2011). *The Persistence of Posters. Graphic Design: Now in Production.* E. Luptun and A. Blauvet, eds. Walker Art Center. 92–111.

Brewer, J. (2018). *Spin releases animated poster campaign for BBC Reith typeface.* Retrieved January 21, 2021, from https://www.itsnicethat.com/news/spin-bbc-reith-animated-poster-campaign-graphic-design-090218/

Cleveland, P. (2010). *Style Based Automated Graphic Layouts.* Retrieved October 15, 2021, from https://research-repository.griffith.edu.au/bitstream/handle/10072/33573/61942_1.pdf

Copeland, B. (2008). *Collossus.* Retrieved September 1, 2021 from https://www.britannica.com/technology/Colossus-computer

Crawford, C. (2002). *The Art of Interactive Design: A Euphonious and Illuminating Guide to Building Successful Software.* No Starch Press

Davis, B. (2019). *Is there gravity underwater?.* Retrieved August 24, 2021 from https://www.mvorganizing.org/is-there-gravity-underwater/

De Bleser, F. (2016). *Generative Design: The NodeBox Perpective.* University of Antwerp.

Denchak, M. (2018). *Water Pollution: Everything You Need to Know.* Retrieved August 23, 2021 from https://www.nrdc.org/stories/water-pollution-everything-you-need-know

Derouin, S. (2019). *Deforestation: Facts, Causes & Effects.* Retrieved August 22, 2021 from https://www.livescience.com/27692-deforestation.html

Dubberly, H. (2004). *How Do You Design?* (1st ed.). Dubberly Design Office.

EPA. (2018). *National Overview: Facts and Figures on Materials, Wastes and Recycling*. Retrieved August 30, 2021 from https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials

EPA. (2021). *Climate Change Indicators: Atmospheric Concentrations of Greenhouse Gases.* Retrieved August 26, 2021 from https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases

Erickson, M. (2019). *Algorithms.* Retrieved January 21, 2021 from https://jeffe.cs.illinois.edu/teaching/algorithms/book/Algorithms-JeffE.pdf

Ferreira, D. and others (2019). *Design Editorial Algorítmico.* Universidade de Coimbra.

Freiberger, P., & Swaine, M. (2008). *ENIAC.* Retrieved September 1, 2021 from https://www.britannica.com/technology/ENIAC

Gettelman, A., & Rood, R. (2016). *Components of the Climate System.* Retrieved August 26, 2021 from https://www.researchgate.net/publication/300418279_Components_of_the_Climate_System

Gibbs, D., Harris, N., & Seymour, F. (2018). *By the Numbers: The Value of Tropical Forests in the Climate Change Equation.* Retrieved August 22, 2021 from https://www.wri.org/insights/numbers-value-tropical-forests-climate-change-equation

Greiner, T. (1996). *Carbon Monoxide Poisoning: Health Effects.* Retrieved August 29, 2021 from https://www.abe.iastate.edu/extension-and-outreach/carbon-monoxide-poisoning-health-effects-aen-166/

Groß, B., & Laub, J. (2007). *Diploma - Generative Systeme Posters.* Retrieved January 24, 2021 from https://benedikt-gross.de/projects/diploma-generative-systeme-posters/

Guffey, E. E. (2015). *Posters: A Global History.* Reaktion Books Ltd.

Hintz, E. (**2018**). *The Mother of All Demos.* Retrieved September 1, 2021 from https://invention.si.edu/mother-all-demos

Hoose, N. (**2018**). *Noise Pollution causes chronic stress in birds, with health consequences for young.* Retrieved August 21, 2021 from http://www.floridamuseum.ufl.edu/science/noise-pollution-causes-stress-in-birds

How do microplastic get in the air?. (**2021**). Retrieved August 23, 2021 from https://www.iqair.com/blog/air-quality/microplastics-effects-on-air-pollution

Isobar. (**2016**). *Interactive poster lets passersby conduct orchestra.* Retrieved August 31, 2021 from https://www.springwise.com/interactive-poster-lets-passersby-conduct-orchestra/

IUCN Red List. (**2021**). Retrieved August 29, 2021 from https://www.iucnredlist.org/resources/summary-statistics#Summary%20Tables

Jabril, S. (**2019**). *The top 10 items that are polluting our oceans.* Retrieved August 23, 2021 from https://www.fairplanet.org/story/the-top-10-items-that-are-polluting-our-oceans/

Kaza, S., Yao, C., Bhada-Tata, P., & Van Woerden, F. (**2018**). *What a Waste 2.0: A Global Snapshot of Solid Waste Management to 2050. Urban Development*. Washington, DC: World Bank.

Ketchum, D. (**2019**). *Five Parts of the Climate System.* Retrieved August 26, 2021 from https://sciencing.com/five-parts-climate-system-21166.html

Kiliç, Z. (**2020**). *The Importance of water and conscious use of water.* Retrieved August 23, 2021 from https://medcraveonline.com/IJH/IJH-04-00250.pdf

Kleist, N., Guralnick, R., Cruz, A., Lowry, C., & Francis, C. (**2018**). *Chronic anthropogenic noise disrupts glucocorticoid signaling and has multiple effects on fitness in an avian community.* Retrieved August 21, 2021 from http://www.pnas.org/content/115/4/E648

Kondratenko, T. (**2021**). *Fact check: Is global warming merely a natural cycle?.* Retrieved August 26, 2021 from https://www.dw.com/en/fact-check-is-global-warming-merely-a-natural-cycle/a-57831350

Korvinus, J. & Mens, D. (**2015**). *So Me Thing.* Retrieved October 15, 2021, from https://studiospass.com/work/so-me-thing-kunsthal/

Kumar, K. (**2021**). *What are the Main Causes of Air Pollution.* Retrieved August 29, 2021 from https://www.medicinenet.com/what_are_the_main_causes_of_air_pollution/article.html

LAFKON. (**2011**). *Bash Scripts for generative posters*. Retrieved October 18, 2021, from https://libregraphicsmag.com/files/libregraphicsmag_1.3_highquality.pdf

Landau, V. (**2018**). *How Douglas Engelbart Invented the Future.* Retrieved September 1, 2021 from https://www.smithsonianmag.com/innovation/douglas-engelbart-invented-future-180967498/

Lopes, D., Martins, P. & Machado, P. (**2018**). *Olhos music fest _branding.* Retrieved October 18, 2021, from https://cdv.dei.uc.pt/olhos/#ref4

LUST. (**2011**). *Posterwall for the 21st Century.* Retrieved January 22, 2021, from https://walkerart.org/magazine/gdnip-9-lusts-posterwall-for-the-21st-century/

LUST. (**2014**). *Camera Postura.* Retrieved October 16, 2021, from https://lust.nl/#projects-5939

Macklin, C. (**2008**). *Screen Design.* In M. Erlhoff, & T. Marshall (Eds.), Design Dictionary: Perspectives on Design Terminology (pp. 349-350). Basel: Birkhäuser Verlag AG.

Maeda, J. (**2005**). *Reactive books.* Retrieved December 4, 2020 from https://maedastudio.com/2004/rbooks2k/index.php

Marselle, M. (**2021**). *Biodiversity: how our health and happiness depend on a thriving planet.* Retrieved August 29, 2021 from https://theconversation.com/biodiversity-how-our-health-and-happiness-depend-on-a-thriving-planet-157261

McGuffie, L. *Chicken Shop Gothic.* Retrieved August 21, 2021 from https://typeverything.com/project/chicken-shop-gothic/

Meggs, P. B., & Purvis, A. W. (**2009**). *Meggs' history of graphic design.* John Wiley & Sons.

Morcos, G. (**2021**). *The Reflection of Effective Interactive Graphic Design.* Retrieved October 15, 2021, from https://digitalcommons.bau.edu.lb/cgi/viewcontent.cgi article=1021&context=csdjournal

MTS. (**2017**). *6 Negative Effects of Improper Waste Management.* (*2019*). Retrieved August 30, 2021 from https://www.metropolitantransferstation.com.au/blog/negative-effects-of-improper-waste-management/

Müller, B. (**2002**). *Poetry on the Road 2002–2013.* Retrieved January 24, 2021 from https://www.esono.com/boris/projects/poetry02/

Nathanson, J. (**2010**). *Water Pollution.* Retrieved August 23, 2021 from https://www.britannica.com/science/water-pollution

Nathanson, J. (**2020**). *Noise Pollution.* Retrieved August 20, 2021 from http://www.britannica.com/science/noise-pollution

National Geographic. (**2019**). *Biodiversity.* Retrieved August 31, 2021 from https://www.nationalgeographic.org/encyclopedia/biodiversity/

National Geographic. (**n.d.**). *Effects of global warming.* Retrieved August 26, 2021 from https://www.nationalgeographic.com/environment/article/global-warming-effects

National Geographic. (**2019**). *Noise Pollution.* Retrieved August 21, 2021 from http://www.nationalgeographic.org/encyclopedia/noise-pollution

National Geographic. (**2020**). *Noise Pollution.* Retrieved August 22, 2021 from https://www.nationalgeographic.org/encyclopedia/carbon-sources-and-sinks/

Neves, M. (**2016**). *Enhancing user experience in graphic design: A study in (Unusual) interaction. Advances in Intelligent Systems and Computing.*

Nunez, C. (**2019**). *Climate 101: Deforestation.* Retrieved August 22, 2021 from https://www.nationalgeographic.com/environment/article/deforestation

OPENRNDR. (**2018**). *Detecting and matching poses from film fragments.* Retrieved October 15, 2021, from https://medium.com/openrndr/detecting-and-matching-poses-from-film-fragments-80c4a8a218b6

Parker, L. (**2019**). *The world's plastic pollution crisis explained.* Retrieved August 23, 2021 from https://www.nationalgeographic.com/environment/article/plastic-pollution

Peeters. M. (**2017**). *LUST: Generating Graphic Design's Future.* Retrieved January 22, 2021, from https://vuartandculture.com/2017/10/27/lust-generating-graphic-designs-future/

Pentagram. (**2021**). *Plastic Air.* Retrieved October 16, 2021, from https://www.pentagram.com/work/plastic-air/story

Pimm, S. (**2007**). *Deforestation.* Retrieved August 22, 2021 from https://www.britannica.com/science/deforestation

Pristia, S. (**2019**). *Generative Graphic Design: Will Algorithm-Driven Design Change our Approach in Designing?.* Retrieved January 23, 2021 from

Rebelo, S., Bicker, J., & Machado, P. (**2020**). *Evolutionary Experiments in Typesetting of Letterpress-Inspired Posters. Proceedings of the Eleventh International Conference on Computational Creativity, September 7–11, 2020.*

Rebelo, S., Fonseca, C.M., Bicker, J. and Machado, P. (2018). *Evolutionary Experiments in the Development of Typographical Posters.* 6th Conference on Computation, Communication, Aesthetics & X (xCoAx 2018) (Madrid, Spain, 2018), 65–75.

Rebelo, S., Martins, M., Bicker, J., & Machado, P. (2020). *Evolutionary Typesetting: An Automatic Approach Towards the Generation of Typographic Posters from Tweets.* In International Conference on ArtsIT, Interactivity and Game Creation (pp. 343-362). Springer, Cham.

Rebelo, S., Martins, M., Bicker, J., & Machado, P. (2021). *Exploring Automatic Fitness Evaluation for Evolutionary Typesetting. In Creativity and Cognition* (pp. 1-9).

Revell, L. (2020). *Climate Explained: what Earth would be like if we hadn´t pumped greenhouse gases into the atmosphere.* Retrieved August 25, 2021 from https://theconversation.com/climate-explained-what-earth-would-be-like-if-we-hadnt-pumped-greenhouse-gases-into-the-atmosphere-141194

Richardson, A. (2016). *Data-driven Graphic Design: Creative Coding for Visual Communication.* London, UK: Fairchild Books.

Ritchie, H., & Roser, M. (2017). *Air Pollution.* Retrieved August 28, 2021 from https://ourworldindata.org/air-pollution

Rodenbröker, T. (2018). *Programming Posters.* https://timrodenbroeker.de/projects/programming-posters/

Ruiter, M. M. (1988). *Advances in Computer Graphics III.* Springer-Verlag Berlin and Heidelberg GmbH & Co. K

Schaub, J. (n. d.). *The Moving Poster.* Retrieved October 2, 2021, from http://www.themovingposter.com

Segalini, A. (1986). *Desktop Publishing.* Retrieved January 16, 2021 from http://www.as8.it/handouts/brief_history_of_DTP.pdf

Selin, N. (2020). *Carbon Footprint.* Retrieved August 26, 2021 from https://www.britannica.com/science/carbon-footprint

Selin, H. (2021). *Global Warming.* Retrieved August 25, 2021 from https://www.britannica.com/science/global-warming

Shiffman, D. (n.d.). *Simple Particle System.* Retrieved August 22, 2021 from https://thecodingtrain.com/CodingChallenges/078-simple-particle-system.html

Silpa, K., Yao, L., Bhada-Tata, P., & Woerden, F. (2018). *What a Waste 2.0.* Retrieved August 30, 2021 from https://datatopics.worldbank.org/what-a-waste/trends_in_solid_waste_management.html

Sixth Mass Extinction of Wildlife Accelerating. (2021). Retrieved August 29, 2021 from https://earth.org/sixth-mass-extinction-of-wildlife-accelerating/

Slattery, T. (2019). *Design in Motion: Animated Posters.* Retrieved January 20, 2021, from https://www.sessions.edu/notes-on-design/design-in-motion-animated-posters/

Smith, D. K. & Alexander, R. C. (1999). *Fumbling the Future: How Xerox Invented, then Ignored, the First Personal Computer*. iUniverse

Sontag, S. (1970). *Posters: Advertisement, Art, Political Artifact, Commodity.* Allworth Press.

Strizver, I. (2016). *TypeTalk: How Posters Work, by Ellen Lupton.* Retrieved December 12, 2021 from https://creativepro.com/typetalk-how-posters-work-by-ellen-lupton/

Studio Feixen, & Giger, J. (2017). *Oto Nové Swiss Poster.* Retrieved October 20, 2021, from https://www.studiofeixen.ch/oto-nove-swiss/

Studio Feixen. (2018). *Air Max Day.* Retrieved October 17, 2021, from https://www.studiofeixen.ch/air-max-day/

Taylor, M., & Watts, J. (2019). *Revealed: the 20 firms behind a third of all carbon emissions.* Retrieved August 26, 2021 from https://www.theguardian.com/environment/2019/oct/09/revealed-20-firms-third-carbon-emissions

The Importance Of Digital Media. (2021). Retrieved September 1, 2021 from https://www.ipl.org/essay/The-Importance-Of-Digital-Media-PKV5JCPH4ACPR

The Facts About Ammonia. (2005). Retrieved August 29, 2021 from https://www.health.ny.gov/environmental/emergency/chemical_terrorism/ammonia_tech.html

Tree Abraham. (2014). *Harriet the Spy.* Retrieved October 17, 2021, from https://www.behance.net/gallery/21703435/Harriet-the-Spy-Moving-Movie-Poster

UNEP. (2018). *Waste not: the heavy toll of our trash.* Retrieved August 30, 2021 from https://www.unep.org/news-and-stories/story/waste-not-heavy-toll-our-trash

Vanetti, S. (2013). *The puddle.* Retrieved August 31, 2021 from https://ertdfgcvb.xyz/p2/the-puddle/

Wartner, A. (2007). *Zeit für die Bombe.* Retrieved October 15, 2021, from https://www.slanted.de/beitrag/zeit-fur-die-bombe/

Weisse, M., & Goldman, E. (2020). *Forest Pulse: The Latest on the World's Forests.* Retrieved August 22, 2021 from https://research.wri.org/gfr/forest-pulse

Weller, C. (2017). *This clever billboard coughs at people who smoke nearby.* Retrieved August 31, 2021 from https://www.businessinsider.com/swedish-billboard-coughs-at-people-2017-1

Wilson, E., & Bernstein, C. (2021). *Why do we need to protect biodiversity.* Retrieved August 29, 2021 from https://ec.europa.eu/environment/nature/biodiversity/intro/

WHO. (2018). *Ambient (outdoor) air pollution.* Retrieved August 28, 2021 from https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

WHO. (n. d.). *Air Pollution.* Retrieved August 28, 2021 from https://www.who.int/health-topics/air-pollution

Wright, B. J. (2016). *Ancient Rome´s daily news publication with some likely implications for early Christian studies.* Tyndale Bulletin.

World Wide Fund for Nature. (n.d.). *Species Directory.* Retrieved August 28, 2021 from https://www.worldwildlife.org/species/directory?direction=desc&sort=extinction_status

Xie, J. (2014). *This Ingenious Subway Ad Activates When the Train Arrives.* Retrieved September 20, 2021, from CityLab: https://www.citylab.com/life/2014/02/ingenious-subway-ad-activates-when-trainarrives/8508/