

Does this chamber remind you of a cloud?







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# Abstract

[EN] A journey into possible fears related to what we cannot understand, the unknown and knowledge, complexity and awe in the phenomena of nature. The thesis aims to tackle the phenomena of unperceptive substances illustrated on the narrative of radiation and dive into the factors that shape those fears. It explores in a critical approach through embodiment alternative perceptions and theories towards existence and engagement with our surroundings (Haraway, 2016). Ultimately, the thesis seeks to cultivate a mindset that embraces the unknown with curiosity and resilience, questioning preconceived fears and opening doors to new ways of engaging with the mysteries of existence by bringing this entities in a level that is perceivable by our bodily sensation.

[GE] Eine Reise zu möglichen Ängsten in Bezug auf das, was wir nicht verstehen können, das Unbekannte und das Wissen, die Komplexität und die Ehrfurcht vor den Phänomenen der Natur. Die Dissertation zielt darauf ab, das Phänomen der nicht wahrnehmbaren Substanzen, die in der Erzählung von Strahlung dargestellt werden, anzugehen und in die Faktoren einzutauchen, die diese Ängste formen. Sie untersucht in einem kritischen Ansatz alternative Wahrnehmungen und Theorien in Bezug auf die Existenz und den Umgang mit unserer Umgebung (Haraway, 2016). Letztlich zielt die Arbeit darauf ab, eine Denkweise zu kultivieren, die das Unbekannte mit Neugier und Widerstandsfähigkeit umarmt,

vorgefasste Ängste in Frage stellt und Türen zu neuen Wegen der Auseinandersetzung mit den Geheimnissen der Existenz öffnet, indem diese Entitäten auf eine Ebene gebracht werden, die für unsere Sinne wahrnehmbar ist.





# Contents

General Introduction	12
Problematizing the topic	12
Research questions	14
Structure	17
Part 1	
Chapter 1: Fear	22
Phenomenology of fear	22
Structure of fear	25
Categorization of fear	11
Self- Existential	26
Social	
Science-Technology-Innovation	
Fear and human experience	31
The necessity of fear	33
Overcoming fear	34
Chapter 2: Radiophobia	36
Introduction to the term	36
Information about Ionizing Radiation	38
Historical overview	41
Political- Social analysis	43
Biases	45
Results of radiophobia	46
Overcoming Radiophobia	48
Conclusion	49
Risk and perception	
Insensibility of radiophobia	

Part 2

Chapter 1: Inquiry	58
Introduction	58
Field research	61
<b>PROTOTYPE 1</b>	64
Experimentation in the direction of sensorium	67
Description of the experiments	
Discussion	
<b>PROTOTYPE 2</b>	74
Description	
Feedback	
Discussion	
Chapter 2: Conceptualizing the artefact	82
Components of the main artefact	82
<b>Meditation exercise</b>	82
Description	
Feedback	
<b>Game construction</b>	87
Description	
<b>Dance exploration</b>	92
Description	
Discussion	
Chapter 3: Title of the artefact	100
Goals and Objectives	100
<b>Workshop</b>	103
<b>Teaser and tutorial audios</b>	110
Findings	113
Conclusions	118
Appendix	122
Bibliography	160



# General Introduction

## Problematizing the topic

This book grew out of the artistic research project enhancing Sensorium of humans in order to feel radiation and a try to cope with the possible fear that the unknown, ungraspable phenomena usually causes. The research led from 2023 to 2024 as a Thesis project at Master Design program, Interaction Design at the Zurich University of Arts ZHdK in Zurich, Switzerland.

Ionizing radiation is a form of energy that acts by removing electrons from atoms and molecules of materials that include air, water, and living tissue. Ionizing radiation can travel unseen and pass through these materials. People are exposed to natural sources of ionizing radiation, such as in soil, water, and vegetation, as well as in artificial generated sources as particle accelerators, and nuclear fission every day. But usually people recall the term of radiation as one strongly connected and interwoven with nuclear accidents, nuclear fusions and the drop of atomic bombs, World War II and Cold war and environmental disasters. The fact that radiation itself is not immediately detectable by human senses and constitutes something difficult to grasp as well as the visible effects, usually harmful and sometimes irreversible and deadly on humans (e.g. acute radiation syndrome), higher possibility of cancer, by the very high energy particles and high exposure to radiation makes people suspicious and it leads to a strong connection of Ionizing radiation with fear. Since this

emotional reaction is not unfamiliar to scientific community, is described already by the term Radiophobia. Radiophobia originally is the fear of radiation as being emotional overreactions to a risk that is actuarially very low, stemming from public ignorance. However, through my previous personal experience with radiation, and knowing so many beneficial applications of radiation, as well as all this regulations and safety guidelines from competent authorities, it was hard for me to relate to this common opinion. While radiation remains invisible to the human senses, it constitutes our atmosphere and earth substances and can be detect in several applications and technical infrastructures, from medicine to electrical energy production. I felt that I need somehow to contribute to maintain to this situation, and try to acknowledge and deliver a more holistic approach. The emotions that are connected with the negative affections of ionizing radiation dominate, so it creates a misconception and suspicion in this whole phenomena that is naturally happening and is a part of our planet Earth. But what are the underlying causes that makes people particularly fearful of radiation? Trying to get a deeper understanding on the reasons and how they shaped people's perception against radiation a further research, qualitative and quantitative, will provide more insights. All the historical events, cultural factors and some personal experiences of individuals are gathered in order to explain this attitude. On top of that a whole analysis on mistakes, wrong decisions, fearmongering and false information by media will also be a way to frame and understand further how radiophobia was established, how rational or irrational this fear is and how public perception is affected and shaped. Additionally even scientists that are studying ionizing radiation and the high risk of exposure to it

they are divided. Trying to moderate the negative effects of radiation there has been developed several different models for the health risks of exposure. However the most common one is the LNT model, which represents a more conservative attitude towards radiation. This adoption maybe relevant but pushes forward the fear.

## Research questions

As a motivation reason to approach this topic and use the design process to deliver this was the following main questions.

How can design challenge each individual to question their own attitudes against unperceivable topics strongly connected with negativity?

How can the discipline of interaction design clarify misconceptions, and allow users to understand their exposure to such radiation and regulate their concerns about?

By delving into the design process, the aim is to provoke contemplation and reflection, encouraging individuals to reassess their attitudes towards the imperceptible. The focus extends beyond merely addressing radiation fears, encompassing broader unperceivable topics associated with negativity. Additionally, I prefer to emphasize the sensory of humans and combined with technologies and met information technologies in rather positive, abstract ways that were more aesthetic rather than explicitly political. For that there are two more questions arising.

Would the transformation of Radiation to something experience able change people's perception?

How the representation of beauty in nature can serve as counterweight on the prejudice towards radiation?

Donna Haraway claimed in her book *Staying with the trouble* that:

*"In this urgent times, many of us are tempted to address trouble in terms of making an imagined future safe, of stopping something from happening that looms in the future, of clearing away the present and the past in order to make futures for coming generations. Staying with the trouble does not require such a relationship to times called the future. In fact, staying with the trouble requires learning to be truly present, not as a vanishing pivot between awful or edenic pasts and apocalyptic or salvific futures, but as mortal critters entwined in myriad unfinished configurations of places, times, matters, meanings."*

Inspired by her work and point of view on how to deal with the complexity, I aim through my research and project to explore different ways about how a more neutral position of this phenomenon can be delivered and how the sometimes irrational attitude that people have towards it can be tackled. Since radiation by nature is invisible and an unknowable quantity I want to experiment with human's experience and turn it to something experience able through embodiment. Our sensorium is limited. But how would human's perception change towards radiation if we were able to see, to hear, to sense or feel it. I want to explore the dance as a medium and how it can draw connections of the interactions of the body and the word around as interfering agents. The general goal of



the project is to leverage the principles of interaction design to help individuals understand possible misconception, underestimation or unreasonable and irrational fear of radiation and exposure. The way it could be possibly happen is by not only showing the extreme situations but also allow people to delve into the journey of radiation and low doses and from the phenomenon's point of view as an always present in atmosphere, so people can have a realistic idea of what is actually happening, but we cannot perceive it. Thus the goal arises to deconstruct the irrational fear in order to address and exhibit this position and change their perception. In the end based on Kai Erikson, the quality of radiation fear can provide insights by drawing attention to the broad, emerging theme of toxicity both radioactive and chemical that characterized a whole new species of trouble associated with modern technological disasters. How can the example of radiation frame and support other unperceivable topics, specifically in the realm of technology? This question positions radiation as a case study to unravel broader patterns and attitudes towards unperceivable aspects, particularly within the technological landscape. The goal is to understand how the fear of radiation can shed light on, and potentially support the exploration of, other imperceptible technological phenomena and if the embodiment and the active body can serve as an efficient mechanism to deal and communicate such topics. As Arcaya claimed "Western scientists and philosophers have posited a separation between the subject of knowledge and the object. If an underlying unity, instead of dichotomy is assumed between experience and its object of knowledge, a different set of concerns arises" (Arcaya J., 1979). This is the key motive to use the interaction design as a discipline and method to embrace user's interaction with

radiation in a way that will open new ways of thinking and dealing with the environmental surroundings as well as individual's perceptions for them. Drawing inspiration from new materialism, the exploration aims to challenge prevailing attitudes towards the imperceptible. Donna Haraway's call to "stay with the trouble" serves as a guiding principle, urging us to be present in the complex configurations of time, space, and meaning. Within this broader context, the fear of radiation is examined not in isolation but as a thread woven into the fabric of ungraspable phenomena. The overarching goal is to question preconceived notions and open doors to new ways of engaging with the unseen aspects of our world. The methodology used in this thesis is based on a combination of the analysis of written texts and deductive prototyping. The analysis of books, articles, philosophical texts and papers is used as the basis for the theoretical section.

## Structure

The structure of this thesis evolves from the theoretical introduction and analysis of the topic in the first Part of the text to the practical based research and design process around radiophobia on the second part. The whole method used to frame the topic was phenomenology. However, as part of the process the specific methodology and point of view is becoming more and more present while my practical involvement with the topic increase. The key concepts that unfolds organically to the first part, mirrors the complexity of the emotion of fear as well as the specific point of view of the analysis around the phenomenology of fear. Phenomenology is the discipline attempt to clarify the manners in which the

object of experience appears to consciousness. As such it concerned with how we are aware of the world and the manner in which we discover meaning in the world. Since many experiences such as emotional sensation, seem blind undirected, and mechanical in nature, the question arises: how are we to give a properly human account for experiences which appears to remove from rational conscious meaning? ( Arcaya J., 1979)

It also reflects the interconnectedness of radiophobia. It lays the foundation for understanding how the perception of subjects has already been shaped due to historical, social, political and cultural reasons and it concludes in the whole second part to tackle how design can play a pivotal role in challenging societal attitudes towards the imperceptible and sets the stage for unraveling the complexities associated with radiation and other ungraspable phenomena. One last key concept that is introduced is how the phenomenology of Radiophobia could also be analyzed. The way the second part of this book is structured aims to explore and cultivate a mindset that embraces the unknown with curiosity and resilience, fostering a deeper understanding of the mysteries that shape our existence. Trying to get a deeper understanding on the reasons and how they shaped people's perception against radiation a process of qualitative, quantitative research and prototype testing was necessary to developed. Each method was designed based on already existing experiments, and was decided in order to provide insides of the users for specific aspects and sub key questions and assumptions. Within this thesis the design approach of the topic goes one step further to create a prototype based on hypothesis and deductions that was test with the small user

sample and the thesis ends with the description from the conceptualization to the making process of this final artifact, the representation in an exhibition setting as well as an extended discussion for further steps and improvements around the design of the artifacts as well as for the efficiency and relevance of embracing resilience and shift the already existing perception.



# Part I

# Chapter 1: Fear

In this chapter constitutes a short introduction and reference to the emotion of fear. However the fear won't be analyzed from a scientific, biological or psychoanalytical perspective, but would shed light to the perception of fear more as an experience. The chapter starts from a statement of different terms of the emotion of fear that are useful for the purpose and the aim of the thesis and concludes to key points after the extended literature review. The goal of this analysis is to wonder and dive more the relationship / interaction with the world in a more emotional, subconscious level.

## Phenomenology of fear

The phenomenological perspective of fear was strongly supporting and framed by the research and writing of phenomenological philosophers as Heidegger and Sartre. Sartre appears to adapt a lot of aspects from Heidegger's philosophy derives from *Befindlichkeit* (and *Stimmungen*). This is why this paragraph will concentrate in Sartre's theory about fear and anxiety, and provide through this a few insights on Heidegger's philosophy.

According to Sartre, emotions are embodied, enactive ways in which we exist in the world and engage with worldly objects, situations, others, and with ourselves, as well as a profound experience, during which emotions are focal points of our consciousness. Emotions are channels through which we

connect with and perceive the world, a way of understanding our surroundings. Thus, this perception arising from emotions, reshapes our reality and existential experience. In this existing world usually we find ourselves within concerns, obligations, and possibilities. And this makes the reality inflexible. The emotions arise according to Sartre when we experience occasions which we are unable to achieve the necessary means. As a result our desires remain frustrated and our practical actions cannot resolve the difficulties that we face. —that emotions arise. An additional layer on this experiences and why they arise this emotions is exactly because this specific situation matter to each individual that experience the situation (Sartre, 1948).

Sartre, in his state of fear, emphasizes an indissoluble synthesis between the affected subject and object, portraying emotions as connecting threads between consciousness and the world. However, Sartre's view of emotions as a degradation of rationality overlooks their role in informing the subject about nuanced aspects of their world, broadening the understanding of fear beyond mere irrationality (Sartre, 1948). On his behalf every emotion, as well as fear should be considered based on two features: the occasion that triggers an emotion and the way that each emotion “tries to deal” with the difficulty. Based on this fear could be either passive or active. Both types caused due to the experience of a threat and especially the perception of a situation that is threatening to one's wellbeing. Passive and active fear attempt to take care of the perceived thread but they differ on how (Sartre, 1948).

In the case of passive fear, we cannot escape from the situation so we face it by negating our consciousness of it,



without any materially changing the world. That means that we do not really make the threat disappear but we simply do not perceive it. In active fear, based on Sartre we adapt a magical behavior which negates the danger with one's whole body, by fleeing. While fleeing, we have magically transformed our world so that it does not contain the threat. However, once more that doesn't disappear the threat. Also fear in Heidegger's philosophy is always fear in the face of one's thrown being in a world which contains entities experienced as threatening. But the fear so disorients one's sense of self that one forgets that it is one's very own being which is in question in one's harried efforts to deal with what threatens (for instance, by one of the two mechanisms of fight or flight). A possible reason why could be Sartre's opinion that fear is unreflective behavior. That means that we live the world through it and then this emotion transforms to "a primarily consciousness of the world." Additionally this emotion is described as a sense of "losing our heads". This also derives from Heidegger's insights that depict fear awakening individuals from unthinking involvement, unveiling a world in a privative manner through a two-pole structure (Heidegger, 1962).

Specifically speaking about the emotion of fear, Sartre based on Heidegger philosophy separates anguish or anxiety from fear since fear is directed to an external threat, while anguish is essentially related to the self and can neither be overcome nor circumvented. Fear is an intricate and pervasive emotion, takes diverse forms and is influenced by both individual experiences and collective societal dynamics. Also correlates with the existence itself and how the situation experiences and living matters to us. In this context and by the lens of the

emotion of fear we cannot oversee the face of which we fear, the Dasein by Heidegger (Heidegger, 1962).

On the opposite hand, anxiety is and can only be prompted by the self. So it is not about any particular thing but about someone being in the world and one's potential well-being in the world. From this perspective anxiety is also related to the projection of one's self into the future based on past experience.

Last but not least, briefly I will point two examples that Sartre is using for framing this differentiation. My fear of falling can be constrained by for example remaining on the path. But on the other hand the experience of anguish, could be related to the possibility of me throwing myself over the edge. But the feeling of anxiety is not only oriented to a future possible scenario but also to the past experience. The best example for this is the example of the gambler who has resolved not to gamble again. Faced with the gaming table, he recognizes that nothing prevents him from ignoring his prior resolution and from continuing along a course which he knows from experience will prove ruinous (Sartre, 1948).

## The structure of fear

Fear, has been extensively explored by experimental psychologists (Strongman, 1973; Zuckerman and Spielberger, 1976), physiologists (Levi, 1975), sociologists (Becker, 1973), and writers, but usually is treated as an objective event rather than a subjective experience. However, the experiential aspect of fear derives from phenomenology, seeks insights into

people's behaviors and perceptions in the face of their fears in order to clarify its subjectivity. Fisher's research on the phenomenology of fear (1970-1974) identifies four core elements. Firstly, fear always involves a "particular actuality," emphasizing the protection of the past over future concerns. Additionally, fear lacks hope for improving the situation, as it strives to protect existing conditions. Fisher emphasizes that fear is not a transient emotional state. It is intertwined with transcendent goals that are obstructed by circumstances, the subject's biographical goals and the history of the individual. Solomon's phenomenological treatment proposes that emotions, including fear, are veiled, pre-reflective judgments and expressions of a person embedded within an "ideology" reflecting the subject's life goals. Fear, according to Solomon, exhibits distinct qualities setting it apart from other emotions. It evaluates the world negatively, strives for separation between the subject and the object of fear, and its principal logic is self-protection.

The structure of fear according to Arcaya J. is the experience of defending past achievements and present possessions when facing imminent threats. In this emotional state, the subject questions the taken-for-granted dependability of the world, the present moment. This state distorts the perception of time as contracted and the space as limited, devoid of creative possibilities.

## Categorization of fear

Fear is a multidimensional emotion and as Tudor claims in the book "Macro sociology of fear" becomes a lens

through which people perceive the world, influencing discourses across diverse domains. It is becoming more complex when it meshes with various societal systems, including moral codes, values, discipline, ethics, ideologies, and more. It influences social interactions, relationships, art, culture, traditions, and even global affairs such as politics, economics, health, population, and safety. (Tudor, 'Macro Sociology of Fear,' 239). Through an exploration to empirical articles that revile the most common phobias and fears of individuals as well as different examples of fear that are used in cultural media, films (horror movies and thriller) and experiences (escape rooms) a draft categorization of this emotions can be made, even if the origins of all the different types could have a common anchor point. The three main categories refers to fear in relationship with me the self (personal fears), driven or influenced by society and related with science, technology, knowledge and innovation.

## Self/existential

The personal inner fear is described from Krishnamurti as one of the greatest problems in life. It entraps the meaning of life to this anxious, guilty, competitive existence, and it is difficult for the individuals to have a completely different approach altogether beyond that. This intense feeling can lead the mind to irrationality and force a life of confusion and conflict, so therefore must be violent, distorted and aggressive". ( Krishnamurti, J.,1969) Everyone is afraid about something; there is no fear in abstraction, it is always in relation to something and is subcategorized in

physical fear that is inherited from the animals and the psychological fears. (Krishnamurti, J., 1969)

## Social

The social aspect of fear is such a complicated and intertwined, it is driven by the already existing structures and construction of civilizations but is also a constant interaction and influence between all dimensions of society. However, for the purpose of the main topic of this thesis only a few elements would be mentioned on this subchapter.

The first key point is the role of social media, how they can shape what is perceived as a threat and how they can contribute as an amplifying mechanism to already existing fears.

Rumors, Propaganda and Stereotypes. Focusing in the example of media on coverage of the 2014 Ebola virus outbreak, as analyzed in "The Economist" in 2015, Hodalska elucidates how frightening metaphors perpetuated public fears, often outpacing the actual spread of the disease itself. (elaborate if necessary). The example above underscores the intricate interplay between societal constructions of fear, media narratives, and the second key point meaning the perpetuation of societal norms through the creation of 'others.' The social construction of fear is a dynamic process deeply entwined with societal values and the creation of 'the other' as a distinct social group (Kaplan et al., 2013). It also highlights the tendency of societies to designate an 'enemy' to attribute challenges to the societal norm. According to

Hodalska the construction of a distant alien 'other' reflects the anxiety of possible inversion of the 'status quo,' within the society. Finally is important to mention the impact does the amplification of threats have on levels of public concerns.

## Science/ Technology/ Innovation

The technological advancement and the innovative in science and knowledge is accompanied except from hopes, optimism for a trans- better future by fear and apprehension. An important factor in shaping public perceptions and responses to them. The overall results and comments on this type of fear arise from specific case studies in innovative examples and how public reacts to each one of them. Based on an example of public concerns for medical procedures, was evidenced by studies the heightened fear towards robotic surgery compared to traditional laparoscopic procedures (Muaddi et al., 2022). As Hala Muaddi points out, based on data analysis regarding the topic, this fear may stem from various factors, including unfamiliarity with robotic technology and uncertainties regarding its efficacy and safety. Furthermore, the marketing implications of such perceptions can exacerbate public anxieties (Muaddi et al., 2022). Based on previous research, Macnaghten mentions that in broader contexts, societal apprehensions towards emerging technologies are shaped by complex social and cultural processes. However he highlights the limited attention given to these processes, which can lead to the emergence of public concerns (Macnaghten et al., 2015). Drawn from the examples of nanotechnology qualitative studies have revealed a sense of pessimism, and a "tragic" mood. This attitude

reflects the lack of trust in science's ability to ensure social progress, especially when intertwined with neoliberal ideologies (Macnaghten et al., 2015). Thus, attitudes towards technologies are related to cognition and is mentioned to be influenced by media frames, ideological predispositions, or emotional judgments (Lee et al., 2005; Scheufele & Lewenstein, 2005; Nisbet et al., 2003; Macoubrie, 2005). Moreover, it is very important to understand how publics interpret and respond to emerging technologies and how concerns about the purposes of this technology, trustworthiness of stakeholders, inclusion and agency, innovation pace, and equity further shape public perceptions and fears (Macnaghten et al., 2015). The main reason is to manage to foster effective engagement and participation of the public. As Macnaghten claims in his article the public concerns and fears are drawn vividly in narratives surrounding various motifs emerge. From tales like "Pandora's Box", saying as *Messing with Nature, Kept in the Dark* and story about "The Rich Get Richer", these themes underscore meddling with nature and unequal distribution of benefits and the overall public's concerns of science, technology and innovation (Macnaghten et al., 2015). Last but not least, Macnaghten mentions the importance of engaging and dealing with those fears as follow: *"these were concerns with the purposes of emerging technology; with the trustworthiness of those involved; with whether people feel a sense of inclusion and agency; with the speed and direction of innovation; and with equity (whether it would produce fair distribution of social benefit)"*. (Macnaghten Phil et al., 2015).

# Fear and human experience

Consciousness is the total field in which thought functions and relationships exist. All motives, intentions, desires, pleasures, fear, inspiration, longings, hopes, sorrows, joys are in that field. The consciousness is divided into the active and the dormant, the upper and lower level - that is, all the daily thoughts, feelings and activities on the surface and below them the so-called subconscious, the things with which we are not familiar, which express themselves occasionally through certain intimations, intuitions and dreams. We are occupied with one little corner of consciousness which is most of our life; the rest, which we call the subconscious, with all its motives, its fears, its racial and inherited qualities, we do not even know how to get into (Krishnamurti, J. 1., 1969). As the fear could be placed in the sub conscious of a person the way it affects humans experiences is not easily revealed but could described only by some effects. As already been said fear disrupts the future goals of individuals, thrusting the subject back to the past when confronted with a threat. Additionally, fear affects the perception of the space. Space, relative to the body, undergoes a transformative connection with time, which becomes distorted in the fearful state. The body, far from being a mere biological machine, acts as the ultimate reference point and perspective. Fear challenges the implicit belief in the body's coping abilities, manifesting reactions such as freezing, jitteriness, and the sensation of "butterflies." These reactions are not mere preprogrammed responses but a manifestation of consciousness. The body's system of skills is confounded, it reveals a dialectical interplay between tacit meanings picked up by the body and reflective awareness.



Finally, fear renders one's characteristic actions ineffective, leads to self-doubt and a questioning of the world. The world becomes ambiguously incomprehensible, lacking clear choices for the body to navigate. This phenomenological perspective highlights how the perception of a threat triggers mobilization and temporarily alleviates the discomfort of fear, distinguishing it from other emotions such as anger, joy, sadness, and grief.

Another way the fear affects the experience of a present reality is really connected with the concept of memories. Through an example light is shed to how this statement is accurate and could be expanded and transformed in many different topics that are related with fear due to historical facts and collective memory.

*“You were ill two years ago, let us say, and the memory of that pain, that illness, remains, and the memory now functioning says, ‘Be careful, don't get ill, again’. So the memory with its associations is creating fear, and that is not fear at all because actually at the moment you have very good health. Thought, which is always old, because thought is the response of memory and memories are always old - thought creates, in time, the feeling that you are afraid which not an actual fact is. The actual fact is that you are well. But the experience, which has remained in the mind as a memory, rouses the thought, ‘Be careful, and don't fall ill again’. Now thought has experienced this state; by observing death it says, ‘I am going to die.’ Thought creates the fear of death, and if it doesn't is there any fear at all? Is fear the result of thought? If it is, thought being always old, fear is always old. As we have said, there is no new thought. If we recognize it, it is already old. So what we are afraid of is the repetition of the old - the thought of what has been projecting into the future. Therefore thought is responsible for*

*fear. This is so, you can see it for yourself. When you are confronted with something immediately there is no fear. It is only when thought comes in that there is fear.”* (Krishnamurti, J. 1. 1969)

The last key element of fear that affects people perception and experience is the creation of biases. Biases are characterized as unconscious judgments for possible results. The tent of people to keep the past alive over a coming threat or change leads to a consistency bias, because it simplifies humans understanding of the world. These biases function also as a tool humans incorporate to reduce discomfort which results from conflict of logic and emotion (Zybrinska P., 2021).

## The necessity of fear

Even if, so far, the fear has been described as something that confuses the people and has a negative aspect attached to it according to "Crime in Contemporary Times" by the Oxford University Press(2009) does not necessarily mean that 'fear' is a negative entity. The absence of fear would mean 'we would allow ourselves to be vulnerable to all sorts of dangers'. Fear, therefore, can be constructive under certain circumstances, by motivating essential action on a particular risk (Dan Gardner, 2009). On top of that it is necessary to accept and face fear honestly and with responsibility in order to achieve self-recognition and healthy functioning of the individual self and the society.

## Overcoming fear

According to Arcaya fear can be overcome by making a commitment to a new goal or value, which can re-establish the subject's connection with time, space, body, and others. Another way to overcome phobias and other anxiety disorders helping is to understand the existential meaning of fears and to make new commitments (Arcaya J., 1979). Only when he affirms a choice which directs him to goals and values different from those endangered can fear be diminished. In this way, he connects himself with an expanding future horizon. Another way to overcome fear as a philosopher supports is by dealing against fear with simplicity and the self with honesty. The simplicity in this context is mean that people can look directly at things and the self without any distortion, and honesty as suggested in the example following to say when we lie we lie, not cover it up or run away from it (Krishnamurti, J., 1969). But the previous suggestion requires another controversial issue, the ability for someone to know or judge efficiently what is right and what wrong in each occasion.



# Chapter 2: Radiophobia

This chapter delves into the main topic of this thesis project regarding the perception of public towards Ionizing radiation. It constitutes an overview of all information needed to be considered in advance for the following design approach of the topic. The chapter is based on a literature review from introduction to the term and the origin of the term to the historical, political social and cultural analysis established fear. The chapter concludes with a number of reoccurring themes of study were identified as well as key points that are necessary for the following practical research. These themes include risk perceptions, accident attention, media effect, trust, values, framing, cultural theory, knowledge, politics, climate change, nuclear waste, engagement methods, communication, public health, and radiation (Shasko et al., 2022).

## Introduction to the term

Radiophobia, shortly defined as the fear of ionizing radiation, has become increasingly prominent in societal discourse, shaping individuals' perceptions, influencing decision-making and contributing to counter-productive behavior and policies (Rice J., 2022). The reason above define the necessity of a deeper understanding of the term. On the other hand, despite its widespread use, there is a notable lack of uniformity in the definition and understanding of

radiophobia. This chapter provide a comprehensive exploration of radiophobia.

The term 'radiophobia' has roots dating back seven years after the discovery of ionizing radiation by Wilhelm Roentgen. Initially it was associated with radio waves and radios and it took almost five decades before a direct connection between radiophobia, ionizing radiation and the risk of nuclear weapons, war and power in an article in the Medford Mail Tribune from 1960 was made.

The American Psychiatric Association's definition of radiophobia suggests the fear or anxiety of radiation being "out of proportion to the actual danger posed by the specific object or situation and to the sociocultural context".

Another anchor point of explaining and framing the term of radiophobia is the nuclear industry. Radiophobia has been a cornerstone in nuclear discourse for the past seventy years, often used as emotional overreactions towards radiation's risks rooted in public ignorance. Radiophobia is also used to describe the shaped public perception and influenced policies related to nuclear technology. Smith suggests that the fear of nuclear energy is not an individual-level psychological abnormality and does not stem from its inconsistency with existing cultural (Smits M., 2006), but in any case Rice proposed radiophobia's definition assessing the perception of the risk as being very low (Rice J., 2022).

Herein proposed radiophobia as the relationship between individuals and ionizing radiation. It posits radiophobia as a complex interplay between actual and perceived risks and health effects of radiation exposure.

However, insights from various sources, including the works of Rice (2022) and Smits (2006), will be used to examine the sociocultural framework of this fear for a deeper understanding, as well as the shaped perception.

Before diving into the radiophobia itself this chapters provide a balanced perspective on the scientific background about Ionizing radiation and introduces a counterpoint to radiophobia that is used to a more informed and rational discourse surrounding ionizing radiation and its societal implications. This is the concept of hormesis, a dose-response relationship characterized by low-dose stimulation and high-dose inhibition. As Bhat claimed the broader applicability of hormesis will be integrated to elucidate the potential benefits and drawbacks of radiation exposure. This insights are drawn through the example of exposure to ultraviolet radiation and how serious health problems are caused by both high exposure and suboptimal exposure to it. (Bhat, 2010)

## Information - Ionizing Radiation

Ionizing radiation, a form of energy, acts by removing electrons from atoms and molecules in various materials, including air, water, and living tissue. It is the "extension of the light spectrum to a much higher energy range". Ionizing radiation encompasses high-energy alpha, beta, and neutron particles, as well as gamma rays and X-rays (Rice J., 2022), excluding radio waves, microwaves, and visible light. This type of radiation can travel unseen, penetrating these materials and affecting them at the molecular level. Ionizing radiation can vary from natural sources in soil, water, and vegetation,

as well as artificial sources such as particle accelerators and nuclear fission.

From medicine to electrical energy production, radiation plays a pivotal role in numerous applications and technical infrastructures. However its beneficial use it can have harmful effects to living organisms, depending on the dose that an organism gets by the exposure to Ionizing radiation.

The potential negative health effects of ionizing radiation were recognized shortly after its discovery (Jorgensen T, 2016) and can be deadly in extreme scenarios. That is the main reason why radiation and all of its applications are regulated by safety guidelines from competent authorities. Analyzing the regulations regarding ionizing radiation, several different mechanisms have been developed. These mechanisms or methods separate in to main ways, passive measuring the radiation dose or the active monitoring of radiation. For the purpose of the design process only the active monitoring would be analyzed. The monitoring of radiation is also divided in two methods, the real time measurement of the dose that an organism is exposed and the measurement of radiation in air, soil, water or vegetation. The more significant example of the first method is Geiger Muller detector that gives a sound signal whenever a particle interacts with the detector. The second method analyzes either on real time or in a short period of time from a few hours to a couple days in vivo the amount of radiation events that happened during the time frame.

The concept of radiation dose, representing the amount of energy deposited per unit mass in an irradiated object, is crucial in understanding the impact of ionizing radiation.



Over the past 115 years, various units have been employed for this purpose (Henriksen et al., 2013, Chapter 5). Some key units include:

- Gray (Gy): The System International (SI) unit, measuring radiation dose. One gray is equivalent to one joule per kilogram, and 1 milligray (mGy) is a thousandth of a gray.
- Roentgen (R): A unit for radiation exposure, indicating the ionization of air molecules. Exposure of soft tissue to 1 R of gamma radiation corresponds to approximately 9.3 mGy.
- Rad and Rem/Sievert (Sv): Developed in 1953, one rad is 100 erg per gram or  $10^{-2}$  joule/kg. The dose is then converted to rem or sievert, with 1 Sv equal to 100 rem. Biological effectiveness factors are considered in this conversion, reflecting the varying effects of different types of radiation on living organisms.

On average, people in Central Europe are exposed to 1.6 milliSievert (mSv) of natural background radiation per year. However in other countries this may vary, being higher or lower. For most people in Europe, the total dose from different sources is between 2 and 5 mSv per year. In Finland, the figure is considerably higher: 7.5 mSv per year. The differences are related to soil conditions or even the distance to the sun.

Other reasons the increase this annual dose could be the nature of a job, any medical treatment or just actions as travelling. A pilot for example, who is often closer to the sun, or a Ski instructor may receive additional dose, because at higher altitudes, the atmosphere above a person is thinner and therefore offers less-effective protection. If you take a transatlantic flight yourself, you will also "receive" additional

dose. An X-ray will expose you to approximately 0.1 mSv of radiation.

Although the concept to radiation turns the attention to the danger and risks that implies Ionizing radiation has proven to be instrumental in a multitude of beneficial applications. These range from mitigating climate change and air pollution through nuclear power to sterilizing food for safety and preventing zoonotic diseases. Additionally, nuclear medicine utilizes ionizing radiation for diagnostic and therapeutic purposes (Bilbao, Lindberg, 2022; Brook, 2012; Baek, 2014; Hong, 2015; Liddle, 2017; MIT Energy Initiative, 2017; OECD-NEA, 2012, 2019; IAEA, 2019; Severine, 2017; Kharecha, 2013; Verma, 2015; Thayer, 1993; World Health Organization, 1994, 1998; IAEA, 2021; Klassen, 2021, 2009; Bilbao, 2022; Jaffray et al., 2015).

## Historical Overview

The historical analysis of radiophobia reveals a complex interplay between scientific developments, societal perceptions, and key events. The inception of radiophobia can be traced back to the late 19th century with the discoveries of X-rays (1895) and radium (1898). The dual nature of radiation, possessing the power to heal or kill, started to emerge, evident in the scandals of the 1910s and 1920s (Weart, 1988, 2012). The tragic case of the "Radium Girls" in 1917 marked one of the earliest instances of radiation-induced injuries shaping public perception.

The 1920s widespread use of radium in various daily products, without considering its harmful effects, further entrenching the negative perception of radiation. The 1927 case of Eben Byers, who suffered fatal consequences from ingesting radioactive Radium Water, garnered extensive press coverage, contributing to early imagery of radiophobia (Macklis, 1993).

The dropping of atomic bombs on Japan in 1945 marked a pivotal moment, instigating public fear of radiation. The subsequent decades, particularly post-World War II until the late 1950s, witnessed increasing anxieties about nuclear technologies, reflecting a duality in societal perceptions (Weart, 2012, 1998; Gamson et al., 1989; Hohenemser, 1977; Lindberg, 2016).

The Cold War era heightened fear during atmospheric nuclear tests, as highlighted (Cuttler, 2014). The partial meltdown at Three Mile Island in 1979 exemplified how radiophobia influenced emotional responses, exacerbated by media coverage and the film "The China Syndrome" (Wills, 2006; Malmshemer, 1986).

The Chernobyl accident in 1986 intensified radiophobia, solidifying the perception of nuclear power as a significant threat. Sociopsychological effects, including evacuations driven by radiophobia, became apparent, with negative health impacts attributed to this fear (The international Chernobyl Project, 1989; IAEA, 2006).

The Fukushima Daiichi accident in 2011 underscored the persistent issue of radiophobia, revealing a systemic failure to address its psychological roots since the atomic bombings of Hiroshima and Nagasaki in 1945.

The fallout debate surrounding nuclear weapons testing played a crucial role in shaping radiophobic narratives, like claiming significant child mortality due to fallout (Sternglass, 1969). The introduction of the biological Model to regulate the health effects of radiation, Linear No Threshold (LNT) model by Muller further solidified radiophobia, suggesting no safe levels of radiation exposure (Calabrese, 201). Claims surrounding nuclear power's collective dose and regulatory approval of deaths annually reinforced radiophobic assertions (Rossin, 2003).

## Political analysis, social structure, propaganda, media influence

The interconnection between radiophobia, social structures, political aspects, and media amplification constitutes a multifaceted web that significantly shapes public perceptions of nuclear energy. The literature suggests that public opinion on nuclear energy is highly politicized and contentious, reflecting conflict-laden dynamics (Shasko et al., 2022). Radiophobia is stemming from institutional and organizational failures, and embodies a retrogression in fulfilling duties and trust towards the public (Freudenburg, 1993; Rice, 2022). This response aligns with decades of discursive, social, and cultural that support the heightened perceived risks associated with radiation (Bhat, 2010). The boomerang effect further contributes to the complexity, with unintended attitude changes triggered by discussions on nuclear safety, thereby influencing public perspectives on

radiation exposure and nuclear accidents (Carson, 1962). The dual-system cognitive approach, where "System 1" relies on fast, emotional responses, and "System 2" engages slow, logical thinking, underscores the nuanced nature of radiophobia's cognitive roots (Slovic, 2004).

Beyond the social and political realms, public sentiments reflect alternative valuations of technological development compared to bureaucratic perspectives. The public's awareness of vulnerability amid complex socio-technical systems contributes to divergent viewpoints (Rice, 2022). Moreover, radiophobia becomes a tool employed by powerful actors to enhance public concerns, limiting reasoned discourse and portraying opposition as irrational (Nadesan, 2018; Rice, 2022). This technocratic control, reinforced by the term "phobia," implies a dismissal of public reasoning, intensifying the challenge of fostering open dialogue and understanding regarding nuclear technology. The intricate interplay of politics, media, cognitive processes, and societal dynamics underscores the complexity of radiophobia's construction and its impact on the collective consciousness.

A different cultural factor that also affects people's perception of radiation is the representation in several cultural media. After the Castle Bravo test, the new fears of radioactive fallout inspired a new direction in art and cinema. Several main characters are shown gaining their extreme powers because of the exposure to really high doses of radiation, connecting them with the alienated 'other' or describing the life in a dystopian future when there are so much radioactive. But is a really common thread in all these movies how they are strong metaphors for post-war radiophobia.

## Biases of radiophobia

While studying the literature around radiophobia is necessary to address and understand biases that are strong connected with all the stakeholders and public. This biases play also an important role to the shaped public's perception. The origins of radiophobia are often oversimplified by scholars, government officials, and industry spokespersons. Instead of delving into the roots of radiophobia, there is a tendency to dismiss public anxiety by attributing it to perceived irrationality. This dismissal is exemplified by categorizing radiophobia as a "serious but curable mental disorder" (Becker K., 2005) and linking it to factors such as a lack of education, adherence to the linear no-threshold theory (Myslobodsky M., 2001), haunting images of the devastation in Hiroshima and Nagasaki (Weart S.R., 2012), and the influence of opportunistic non-governmental organizations that exploit public emotions (Rice J., 2022). One more cognitive bias is the anchoring bias, defined as "the tendency, in forming perceptions or making quantitative judgments under conditions of uncertainty, to give excessive weight to the starting value (or anchor), based on the first received information or one's initial judgment, and not to modify this anchor sufficiently in light of later information" (American Psychological Association, 2021). Finally, the invisibility of radiation as a perceived phenomenon makes it highly susceptible to influence, strengthening the impact of anchoring bias. Factors such as inherent uncertainties and the lack of direct attribute ability to potential health impacts, especially in low-dose exposure scenarios, contribute to the

pervasive nature of the anchoring bias in relation to radiophobia. As most people do not have any direct experience with radiation, their perceptions are influenced by the anchoring bias. Indeed, in the majority of cases, the only relationship that an individual will have with either radiation or nuclear power is through media coverage or, more likely, popular culture portrayals. The images and the often sensationalistic nature of any news related to nuclear power, particularly nuclear power accidents linked with their health impacts are largely radiophobic in nature.

## Results of radiophobia

Although the results of radiophobia are not the focus of this research, a brief review will be provided in this paragraph to provoke a second thought about how the harmful effects of a potential radiation-related accident can encompass various underlying factors that are intricately tied to the existing emotion of fear. Radiophobia manifests multifaceted consequences across various domains, highlighting the intricate interplay between public perceptions, individual behaviors, and societal structures. In the aftermath of major radiological incidents, the economic fallout is palpable, as seen in the devaluation of goods from affected regions and consumer aversion to specific food items and is intricately tied to the public's perception of radiation contamination (Pastel R.H., 2004; Miyata T., 2018). An

example of the sociopsychological effects of radiophobia is evident in the stigmatization of populations affected by radiological incidents. The term "Hibakusha" in Japan, translating to "person affected by exposure [to radiation]," encapsulates the discriminatory experiences faced by these individuals. Mental health studies on survivors of Hiroshima bombings reveal a complex interplay between the trauma of the event and the enduring anxieties about health effects and societal stigmatization, with the latter proving to be a more significant factor influencing mental well-being (Nozomu A., 2012; Shinfuku N., 2009). Chernobyl's aftermath further exemplifies the psychological toll, with heightened anxiety, stress levels, increased rates of bullying, and substance use. The ripple effect extends to societal structures, reflecting the profound influence radiophobia has on collective mental health and well-being (Havenaar J.M., 2005; Morrey M., 1996; Sawano T et al, 2018; Teraya T. et al., 2020). In addition, the impact of radiophobia extends to reproductive health, with observable increases in abortion rates in countries like Denmark, Italy, Greece, and Finland. While methodological challenges hinder the precise quantification of these effects, the observed trends underscore the complexity of decision-making surrounding reproductive choices in the face of radiophobia (Knudsen L., 1991; Spinelli A, 1996; Trichopoulos D, 1987, Avuvinen A, et al. 2001). The Fukushima Daiichi accident provides a contemporary echo of these patterns, where stigmatization of agricultural produce resulted in economic hardships. These instances collectively underscore the importance of understanding the multifaceted impacts of radiophobia, emphasizing the need for comprehensive strategies.



## Overcoming the fear of radiation

Radiophobia has been fueled by the pervasive adoption of the Linear No-Threshold (LNT) model in radiation risk assessment. The LNT model, established in 1958, assumes that even the smallest dose of radiation contributes to disastrous health effects, primarily cancer and genetic harm. This model has been a significant factor in instilling fear and shaping societal attitudes towards nuclear technologies (Cuttler J.M., 2014). However, in literature this narrative has been challenged as a possible way to dispel the fear associated with radiation.

Another compelling argument emerges through the exploration of radiation hormesis, a phenomenon wherein low doses of radiation have been shown to have beneficial effects. Numerous studies, highlight the historical use of low-dose radiation for medical purposes, such as curing pneumonia (Cuttler, 2014; Calabrese, 2013; Feinendegen et al., 2013). The threshold for harmful effects, as evidenced by the tolerance dose of radiologists in the early 1930s (Cuttler, 2013), challenges the LNT model's validity, suggesting that not all radiation exposure leads to harm. This idea has been supported as a reason to reexamine the established regulation. The LNT model, being misused as a predictor of excess fatal cancers, fails to consider the potential beneficial effects of radiation. Additionally, the rate of spontaneous DNA damage is significantly higher than that caused by radiation, and organisms can tolerate large doses if delivered gradually, without overwhelming defense mechanisms (Billen

D., 1990). Another argument against radiophobia is rationality. As Zafirovski suggests the logical thought and behavior based on sound reasons, can serve as a coping mechanism to counteract this irrational fear (Zafirovski M., 2003). Rational discourse involves challenging the ideological linkages that connect all radiation exposure, whether human-made or natural, to excess health risks. In conclusion, promoting a rational perspective involves the beneficial applications of radiation, ranging from mitigating climate change and air pollution through nuclear power to food sterilization, preventing zoonotic diseases, and advancing nuclear medicine (Bilbao, Lindberg, 2022). These applications demonstrate the positive aspects of radiation and challenge the prevailing irrational fears associated with it.

## Conclusions

After this extensive literature review on Radiophobia, several crucial points need to be highlighted, aiming to elucidate how these key points will be utilized in the design process and how they will determine the foundational elements and initial framework of the entire research. These key concepts navigate through the relationship between perception and risk, the style with which the literature approaches radiophobia - contrasting the scientific, almost sterilized approach with the phenomenological perspective that considers fear as a subjective experience. Additionally, it will be explored how the literature addresses the nature of ionizing radiation, emphasizing its invisibility and humans' inability to feel it.

## Risk and perception

The relationship between perception and risk is a central theme in every analysis that tries to explain how the fear about radiation is already so well established. As highlighted by the OECD Nuclear Energy Agency the actual risk remains constant, but public perception defines the reality of the situation (OECD, 2003). It is also connected to the distinctions in the public's mind regarding different systems, where high casualties with low probability are perceived as riskier (Waits C. R., 2007). An example of this is the common fear of airplane crashes, while automobile fatalities are accepted. Additionally there are dynamics binding knowledge, perception, and the complexities of risk, particularly in the context of radiation exposure. The public attitudes toward nuclear issues laid the foundation, emphasizing the need for specific indicators to deepen our understanding of the interplay between knowledge and risk formation (Stoutenborough et al., 2013). However, the conventional Knowledge Deficit Model, falls short by assuming that inundating individuals with information inherently leads to rational decision-making but do not efficiently deals with the risk (Wynne, 2006). The promotion of rationality overlooks aspects such as the loss of trust and the emergence of dread as influential risk signals and creates a divide between laypersons surrounded by specialized knowledge they may not comprehend fully and experts and regulatory oversight. This dichotomy prompts an essential argument: blind trust in specialized knowledge may sideline public concerns and hinder a more inclusive discourse (Wynne

B., 2006; Rice J., 2022). However, instances of recreancy, where institutional actors fail in their responsibilities, contribute to societal unrest and fear (Freudenburg, 1993; Khasawneh, 2018). Methodical and calculative thinking, serving as a universal principle structuring human activity, becomes the predominant criterion of collective understanding (Albrow M., 1990). This is evident in the expression of rationality through individual cognition and perceived legitimate choices of action (Brubaker, 1984; Rice, 2022). However, an essential argument arises against this approach. As Freudenburg underscores, recreancy signifies a failure of institutional actors to meet societal trust expectations, leading to social and political unrest (Freudenburg, 1993). This unrest may manifest as technophobia or generalized anxiety in response to the introduction of new technologies, indicating public skepticism about the due diligence exercised by powerful actors in government and industry on their behalf (Rice J., 2022; Khasawneh O.Y., 2018). This critique prompts consideration of alternative avenues for expressing concerns and fostering a more inclusive and transparent societal dialogue. Clarke's notion of possibilistic thinking is explored, emphasizing its role in encouraging a broader range of ideas, particularly relevant when dealing with novel technologies where data is limited. This approach counters the tendency towards groupthink and allows for a more comprehensive risk assessment (Clarke L., 2006; Rice J., 2022). The exploration of radiophobia in existing literature uncovers a clinical, scientific outlook juxtaposed with a phenomenological approach that acknowledges fear as a subjective experience. This dichotomy introduces a layer of intricacy in comprehending public sentiments and devising effective communication strategies

(Stoutenborough et al., 2013; Wynne B., 2006; Rice J., 2022). Echoing Weber's insight, science and technology epitomize formal-instrumental rationality, yet they fall short in addressing ethical questions, values, and providing a comprehensive understanding of the world. The inherent limitation of science in providing answers to fundamental human queries, emphasizing the pivotal role of substantive rationality in shaping societal discourse (Weber M., 1917). An important factor explaining the emergence and subsequent stability of radiophobia is the fact human perception is largely blind to probability. Instead, the possibility of a risk materialising is a significant driver in terms of perception (Lowenstein G.F., 2001; Rottenstreich Y., 2001; Slovic P. 2007). In the case of radiation, the mere possibility radiation exposure – irrespective of the actual dose is not enough. Also stress or the emotions that affect cannot be used to dismiss risk perceptions as “irrational” or “emotional” (Reynolds B.J., 2011).

## Insensibility and the results

Exploring the nature of ionizing radiation delves into its invisibility and the societal significance attributed to it. The interplay of visibility and invisibility in shaping public discourse on radiation is crucial, with popular culture acting as a powerful influencer. In order to establish a meaningful relationship with radiation, which is imperceptible to human senses, efforts are made to "make it visible." Popular culture, instrumental in conceptualizing the world, plays a doubly important role, especially considering the limited direct

experiences with radiation. Throughout human history, interpretations of radiation result a diverse range of imagery. Popular culture often features second-order narratives, portraying radiation as an existential threat through mutated beings and subtle messages. This imagery, rooted in the salience of information in memory, strengthens the somatic markers associated with radiation. This influence becomes pronounced during nuclear incidents, amplifying radiophobic behaviors and decisions. Contrary to the misconception of radiophobia as concern for something "imaginary," this approach offers a subjective exploration, challenging existing perspectives on the fear of radiation (Novikau A., 2017; Rice J., 2022).

In summary, this chapter shows crucial insights from the literature review, guiding their integration into the research design. The example of Kerala, where natural background radiation is notably high (Wynne B., 2006), emphasizes the subjectivity in perceiving risk. Understanding diverse radiation exposure scenarios becomes paramount. To address radiophobia, deeply rooted in cognitive heuristics, a proposed paradigm shift in communication (Shellenberger M., 2018; Ropeik D., 2016). This shift, recognizing heuristics and biases, aims to cultivate new affective imagery, transcending mere dismissal. Inspired by Curie's observation, the proposal advocates for collective understanding and alternative expressions, offering a constructive path to mitigate the fear of radiation.

Additionally, from my own perspective and approaching the whole topic from the subjectivity of the body

and the experience and after approaching the emotion of fear from its phenomenology I would like to develop, interpret and draw insights for Radiophobia through the lens of phenomenology. The main motive for this analysis arises from the design practice that tries practically to challenge and explore the topic considering always the phenomenology as guidance, hoping that this exploration will also give me tools and useful feedback to frame the theoretical research of radiophobia from a phenomenological point of view. So, based on the phenomenological approach of fear by Heidegger and Sartre and considering the phenomenology of the body and the main ideas of Merleau-Ponty about it we can conclude in several aspects of the phenomenology of Radiophobia. First, the most popular opinion about the body is that is defined and limited compare to the surrounding environment. Since dualistic thinking and perception as well as the Cartesian perspective of the world are defining the way we as humans perceive our existence we are somehow trapped in this approach where the body- ourselves- need to be protected from possible threads that come from the outer world, the environment around us. On top of that, considering the individuals subjective experience as the way that someone understands the world and evaluate the risk, radiophobia could be a result of the past experience on previous historical accidents and incidents related to radiation that travels through time via memory and common intelligence as well as the reflection of a possible accident happening in the future. This two perspectives of past and future can shape the Dasein of the present moment of individuals and create an underlying anxiety or fear on the phenomena itself, which has not yet arise. Additionally based on Sartre's opinion if we consider Radiophobia as passive fear the Western society is

creating a cope mechanism by negating our consciousness of it, without any materially changing the world. That means that we do not really make radiation disappear (that would also be impossible since the absence of radiation doesn't allow life form) but we simply do not perceive it. If we also characterize Radiophobia as a case of active fear following the fleeing behavior I consider that the whole society by fleeing magically transform our world so that it does not contain the threat. If I am allowed to elaborate a bit further on this direction, the society either tends to forget or not deal with phenomena that doesn't confront with the idea of safety and well being.





# Part II

# Chapter 1: Inquiry findings

## Introduction

*“Radiation is invisible, an unknowable quantity. People don’t feel in control of it, and they don’t understand it. They feel it is imposed upon them and that it is unnatural.” (Alison G., 2011)*

How can the fear of radiation be maintained by designing a processes that would familiarize and make people quite their egocentric point of view and accepting the “existence” of other agents? To promote the understanding of the complexity of radiation and exposure and open up different perspectives the design exploration goes from various try outs in sensorium, embodiment, technology, storytelling until the final artefact was formulated. The exploration of complex and ungraspable phenomena, such as radiation, demands a theoretical framework that could suggest a mode of understanding. The whole design process and how I am planning to approach the research topic with the design practice delves out of the two main areas. In the first part focuses on the results of the literature review around radiophobia and the secondary part focuses on the aim and objectives of the research, including my personal perspective, experiences and contribution through design. The conclusions from the literature from the exploration of fear in general to radiophobia and the underlying scientific phenomena shed light on the perceptions of actual danger and risk, as well as the fundamental fact that humans do not

possess the sensory capability to perceive radiation. My one perspective as a counterweight to this attitude is based on theoretical foundations such as embodiment, phenomenology of the body by Merleau-Ponty, and Karen Barad's theory of matter, in order to bridge the gap between abstract concepts and tangible experiences. Through embodied experiences, creative practices, and non-anthropocentric approaches, I try to challenge preconceived notions, disrupt common perceptions, and foster new ways of engaging with complex phenomena like radiation.

According to Merleau-Ponty's theory about body I adapted several key aspects, in order to think about how to explore the connection of humans embodied involvement and ungraspable phenomena. First according to him the self can't be conceptualized without the body and its entanglement with the outer world and this relationship between the body and the outer world can also be used as a feedback to certain forms of self-knowledge (Russel K., 2014). Additionally, he views the humans as subject, i.e. embodied and he differencing the preexisting phenomenological opinions that combine the subject with the consciousness. He insist that the intentions and praktognosia of the body are shaking down the form of dualism (Russell K., 2014). In Merleau-Ponty's Phenomenology the body is an undivided unity, and it is meaningless to talk about the perceptual processes without referring to all the senses, to the total physical environment in which the body is situated, and to the "embodied" intentionality (Svanæs, D. 2013). In this phenomenological approach the subjective experience receives a significant importance because it links to the idea of openness, meaning that the body is open to the world, not

necessarily as vulnerable but also as part of it. The openness of being within this framework of the body is important for the way I approach and research the connection between embodiment and complex, unperceivable phenomena because it implies philosophical investigations of nature, flesh, expression, institution and so on (Flach S., 2011). Therefore setting the body as the primary element of perception gives an importance to the role of movement in shaping our engagement with the world, since Merleau-Ponty's phenomenology seeing us existing and acting in the world as bodily beings (Keat, 2004; Svanæs, D. 2013). Elaborating further this statement the bodily beings have the ability not only to act in this world through concrete movements but most important for this research approach to reflect and communicate through abstract movements alternative futures (Svanæs, D. 2013). Since perception is intentional depending on the nature of our bodies relating to the world and others, the understanding of the world comes only by experience and action. In this sense enactivism positions action as fundamental to cognition about our nature and movement as knowledge of the lifeworld through experiences, where lifeworld is world we live in and not the world in front of us as Husserl suggests, and cognition about our nature through experiences (Johnson, 1987; Morris, 2008; Fraleigh, 2018). My research practice adopts the ideas above but is mainly affected by previous personal experience. As already mentioned a main tool for the design exploration would be the dance approach. In dance philosophy, dance phenomenology is also tightly connected to embodiment and cognition through the experience of the body itself and suggests this experience what matters in order to investigate our existence and understand how and why of our reality.

## Field research

I make a hypothesis that if humans get to know more about radiation or are able to sense radiation this will bridge the gap between the perception and the actual danger. Trying to understand the more suitable way that would fulfil the purpose of this design process there should be evaluated both ideas. The one direction indicates the information and education of the public around the topic of radiation but without creating emotional responses to already existing accidents that has already shape the perception towards radiation. So, then the possibilities on researching practically through the design process are limited between the documentary or journalistic approach and the guidance of graphs and diagrams as a new language to communicate and explore a scientific phenomenon. To gauge the perception of the target group, namely students in the wider Zurich area, regarding radiation and the factors influencing their attitudes, a quantitative research approach was deemed necessary. Subsequently, a questionnaire was meticulously developed to serve as the foundation for a systematic exploration.

The development of the questionnaire involved a strategic approach. Its primary objective was to assess and comprehend people's opinions about radiation and extrapolate these insights to encompass broader technological and scientific advancements. Drawing inspiration from existing surveys in Japan, the USA, Britain, and Canada, the questionnaire aimed to collect data on perceptions, attitudes, and fears related to radiation and technology. This initiative aligns with the overarching goal of contributing empirical evidence to

support the research on the widespread fear of radiation and its potential applicability to broader scientific contexts.

The experiment's aim was to amass data, evaluating how individuals in various regions perceive radiation and examining whether these perceptions extend to new technologies and scientific fields. The survey also sought to identify key factors, including cultural, educational, and demographic variables, influencing people's fear of radiation and its extension to other scientific domains.

The questionnaire's creation and deployment represent crucial steps in gathering essential data to substantiate the thesis's overarching argument. By synthesizing existing surveys from different regions, the research demonstrates its relevance to a wide range of settings and populations, enhancing its credibility.

The questionnaire, was disseminated primarily among students at ZHdK, Department of Design, and individuals from mechanical engineering and biology departments, ensuring as much as possible a diverse audience. To capture a wide array of perspectives, further distribution to different target groups is planned. Following the collection of responses, the survey data was analyzed to identify patterns, trends, and variations in the fear of radiation and its generalization to other areas of technology and science. The evaluation of this process adhered to epistemological principles, addressing challenges such as the small participant pool and non-representative sample, with a focus on efficient research practices.

Although the sample of participants wasn't big enough there are several results that could help further the development of the artifact and the whole design process for the topic. The first crucial finding regards the knowledge that people have about Ionizing radiation and how aware they are for the negative and beneficial applications as well as health risks and regulations. Regarding this most of the people claim that they are neutral towards ionizing radiation but the overall sample tend to be negative since just 10% believe that Ionizing radiation can be moderately beneficial. Another factor that is used to criticize this neutral opinion is the fact that most of the people do not know at all the scientific institutions that are in charge of informing educating and moderating applications of ionizing radiation as well as the natural background radiation and the human's daily expose to it.

Another key element was revealed when people were asked if there were able to see or sense radiation will affect them and help them to reduce any possible underlying fear. Some people claimed that the constant sense of radiation presence could sabotage even more people's perception and probably amplify the panic since the education of public is not sufficient enough. Another argument against transforming radiation to something experience able is linked with the origins of radiophobia to a more social level as well as the relationship between memory and emotion of fear illustrated around the idea that people tend to forget and as a result worry less. On the opposite hand the majority claimed that the idea of visualizing radiation will help to clarify and be aware of this "unknown substance", reveal the whole range of radiation and what it truly means, can fight stigma or even work as a detecting mechanism and a way to avoid dangerous



situations. However, it would be definitely important to link it to the right type of visuals and include scientific information that will gain the trust of the participants.

## Prototype Untitled #1

The prototype aimed to delve into the historical aspects influencing negative perceptions of radiation and uncover the reasons behind the formation of radiophobia. It was more a representation of the analysis made so far and driven by a main question how an engaging experience could motivate awareness. Since the idea of challenging humans sensorium seemed excluding the multidisciplinary and intertwined factors that can affect people's perception a more broad approach was applied for the conceptual development of this prototype. As an inspiration for this prototype was the artistic project/ photography collection of Susanne Kriemann "Falsche Kamille" (Kriemann, 2017). Her project is an investigation of renaturation of Uranium mining area and her approach to make the radioactivity of the soil visible.



*Figure 1: "Falsche Kamille" by Kriemann Susanne, 2017*

By creating an installation, a dark room served as the testing ground. Participants, equipped with a UV torch and headphones, entered the room to encounter printed photos related to radiation, including images from nuclear applications, the Manhattan Project, and nuclear accidents. Texts supporting radiation and advocating resilience were written atop the photos with a UV marker, urging participants to explore and learn. However, a UV sensor triggered an unsettling sound through the headphones when attempting to read, symbolizing the disruptive factors that contribute to a negative bias against radiation not letting them explore the whole range and complexity of the phenomena. The whole installation accompanied by a Geiger counter sensor which worked as the binding bridge between people and radiation in the space, transforming real time data to sound signal whenever a particle was reacting with the detector. During the exhibition opening time and after experiencing the

installation room the participants were asked for extensive feedback.



*Figure 2: Prototype untitled #1, photo by Duy Bui*

The comments received from the participants differ from each other and could contribute in various aspects of the designing process, the representation in the exhibition setting and in order to define the encounter point of predefined notion and a new proposal through the interaction with the installation.

Overall, the experience was described with many various ways and diverse from scary to trippy. Although, the message about supporting radiation in contrast with the reasons that shape the negative opinions about it was clearly and directly communicated with the visitor the interactions between the

artifact and the visitor were “flat”. That means that the idea of entering the room is already engaging with the participants but the installation journalistic setting doesn’t help the participants engage with the phenomena and the topic itself. Even if the use of darkness and the set of the room promote imagination the usage of text exclude people that cannot read or they are lazy to reach the information. Another key point was that the metaphor of the sound was difficult to grasp and also covered and mislead people so they couldn’t get the idea of tangible presence of radiation. Finally, the neutral position and not provoke radiation and overlook the risks or dangers should be showcased in the artifact concept.

This feedback provides insights for refining the prototype, focusing on ways to mitigate negative influences and fostering a more open engagement with the complexities and beauty of the radiation phenomena, aligning with the broader goals of the thesis research on radiophobia.

## Experiments in the direction of sensorium

As a result from the previous prototyping testing in combination with the results of the short questionnaire and the need of users to engage more with the unperceivable radiation the direction of using the sensorium and the transformation of information to a sense able result was decided as the most effective to challenge people’s perception and address a more open mind point of view driven by

curiosity and acceptance of the awe phenomena of planet Earth.

The adopted approach emphasizes qualitative research through small interventions, experiments, and prototyping. This new exploration involved a series of experiments and try outs to delve deeper into the topic, aiming to understand diverse perspectives and approaches within this field (Shasko et al., 2022). It also gives a variety of ways to approach and effectively challenge people's attitudes and perception by recreating an experience and drastically make them involve and interact with the natural processes of the atmosphere. This possibility delves the creation of an experience and extend the human senses to the phenomena that humans cannot perceive because the human mind is deeply dependent upon features of the body, which have causal and constitutive roles in cognitive processing (Varela, Thompson, & Rosch, 1991). Based on Alva Noe: *"The world makes itself available to us through our interaction with it; and what we perceive becomes a function of what we know how to do. Thus, all perception is intrinsically active and thoughtful we not only purposefully select what to direct our attention and focus towards, we actually have to "reach out and grab it" with our sensing organs. Our capacities to look and move and smell make it possible for us to perceive; but effective perceiving cannot happen unless we develop these capacities into sensorimotor knowledge... In actively encountering the way in which how things look varies with movement, we directly encounter how things are... The more we are able to go through the processes of developing our bodily sensorimotor skills in relation to our other perceiving organs and our environment then we are able to directly perceive more of the world, particularly*

*if we understand perception as an action that is meaningful and that makes sense.” (Noë, 2006)*

The emphasis shifted towards discovering everyday objects that emit ionizing radiation and exploration of possible anxiety that comes with the communication of that. Interventions and experiments were conducted with a playful way, emphasizing their non-confrontational and non-violent nature, echoing the approach of Nadesan (2018). The overarching goal was to bridge the gap between scientific knowledge of ionizing radiation and the everyday experiences of individuals. Educational and scientifically oriented initiatives were integrated into the research, focusing on principles such as data and examples, comparison, and critical situations highlighting danger versus non-danger. The research also delved into the impact of cultural, social, and historical events on people's perception of radiation (Rice J., 2022). Fake radioactive scenarios were created to observe and analyse reactions, providing valuable insights into the intersection of fear and everyday products. The shift to the sensorium experimentation is also inspired by the fact that our embodied knowledge can be accessed by our soma-sensory awareness as Fraleigh suggests (Fraleigh, 2000).



Figure 3: The cloud chamber, source Wikipedia (Cloud chamber)



Figure 4: Geiger counter

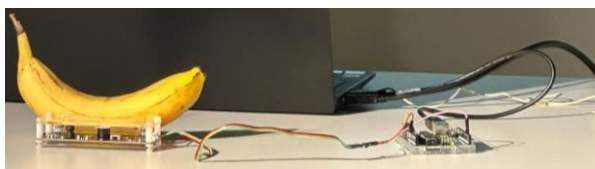
The incorporation of a cloud chamber, a tool for visualizing radiation, further enhanced the educational and scientific aspect of the research. Small experiments were designed to observe how individuals perceive the world and engage with educational content about radiation. This qualitative research approach aimed not only to understand fear but also to educate and bridge the gap between scientific knowledge and everyday experiences.

## Description of the experiments

The first experiment explore the sonic perspectives of Ionizing Radiation using the Geiger Muller detector. The overarching goal was to challenge and reshape the auditory experiences related to radiation detection. By leaving the detector in a space for an extended period, the emitted sounds, indicative of photon detections, to one or two sounds every 10 seconds, were examined. This intervention aimed to investigate how a new auditory element might alter human perspectives, evoke curiosity, or potentially fade into the background. Additionally, an auditory exploration was crafted, ranging from the background radiation level to extreme scenarios within the room. This aimed to provide participants with a spectrum of radiation-related sounds, fostering a nuanced understanding of auditory responses to varying radiation levels. The final part of this experiment introduced the interaction between materials radiation and human's perception. Materials known to emit radiation, such as bananas and glazed ceramic pieces, were placed in

proximity to the detector. The experiment observed changes in the frequency of photon detections, exploring how different materials influenced radiation-related sounds.

By the end of the experiment, participant feedback was actively sought. The responses from participants provided valuable insights into their responses to the introduced sounds and varying radiation scenarios. The feedback was directed to the connection between sound and attention and information's effectiveness. There was a significant interest to explore the everyday sources of ionizing radiation, although people would doubt about the safety of the everyday products that emit radiation if there was no clarification about the response of the detector to the different radiation levels. However, a very contradictive opinion was that both the sound signal of the detector as well as the amplified outcome of the products were not perceivable. This experiment contributed to the broader exploration of ionizing radiation perception, emphasizing the role of sound in shaping human understanding. The findings shed light on how auditory cues related to radiation can either captivate attention, induce curiosity, or become normalized within everyday auditory landscapes. The integration of materials and varying scenarios adds depth to our comprehension of how different contexts influence our sonic engagement with ionizing radiation.

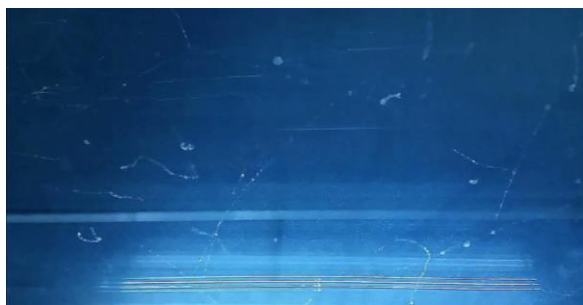


*Figure 5: Experiments using Geiger counter and everyday life objects- bananas- know for the emission of Ionizing radiation*



The second experiment conducted involve a sensory synergy and introduces a unique fusion of visualization and soundification of background radiation to enhance participants' understanding and perception of background radiation and challenge the multisensory design as methodological approach for the final artefact. The experiment employed a Cloud Chamber for visual representation and a Geiger Muller (GM) detector for auditory engagement. The simultaneous exposure aimed to provide participants with a multi-sensory experience, combining visual and auditory stimuli related to background radiation.

Participants were presented with an archive video projection of a Cloud Chamber, a device that visually represents particle traces caused by ionizing radiation. This component focused on the visual aspects of background radiation, offering an alternative to numerical or abstract representations.



*Figure 6: Screenshot from the visual output of a Cloud Chamber, source <https://www.youtube.com/shorts/OPfwopDsD1Y>*

Simultaneously, participants experienced the auditory environment of background radiation through the real time

response of the GM detector. The detector emitted sounds in response to photon detections, providing an audible representation of radiation levels.

Following exposure to both visual and auditory stimuli, participants were questioned about their experiences. The feedback sought to understand the effectiveness of combining visualization and soundification in conveying the concept of background radiation. The feedback shed light to different aspects such as the clarity of information, emotional responses, and the synergy between visual and auditory stimuli. In particular the emotional response was mostly confusion and doubt due to the asynchronized elements of visuals and sound. People thought that the lack of coherence between the information from the two different elements didn't help to gain understanding. Another key information from the feedback was the density of the different elements. As pointed out there is the potential of the visuals to be really overwhelming: *"I don't want to imagine what the visuals would be in extreme radiation levels"*.

## Discussion:

The experiment aimed to assess how the dual sensory input influenced participants' comprehension and emotional engagement. It highlights though the inefficacy of synergizing visualization and sonification in conveying background radiation. Comparing the feedbacks from the different user tests conducted and especially the fact that a multisensory experience could be very complicated for communicating the complexity of the phenomena and the fact that sound was

misleading people and didn't efficiently communicated the purpose of its usage the visual representation was selected as the key element for the artefact. Additionally, characteristics that can be implement in the design process are the engagement of the user with different scenarios.

As described before and through the experiments that conducted the mediator between the unperceivable ionizing radiation and the human senses are the already existing detectors that has been developed to monitor and capture the phenomena. The identical use of them couldn't make any significant difference to focus on.

Another interesting key element that was taken in consideration for the designing approach to the whole topic is the already existing ways to communicate the information / measuring data to the broad audience. Meaning that there should be a short description of the different types of information published in open access. The main one and the easier for someone to get is a visualization of the dose that a human organism gets after the exposure to specific amount of radiation. The other main way to communicate with the public is by publishing the activity of the most known radioisotopes. Based on these two conclusions, a second prototype was developed further to integrate the benefits and extra goals to a more concrete set up.

## Prototype Untitled #2

The idea of this prototype delves from the findings of the previous process and experimentation in the field of

sensorium and the relationship with ionizing radiation and it is enhanced by reflecting on my research questions and the goal of the whole thesis through the artefact. There is one assumption made in this approach, that the only way humans could perceive a stimulus are the developed detectors.<sup>1</sup>

This prototype follows the same principle as the experiments before and explores the sonic perspectives of Ionizing Radiation through auditory cues by using the Geiger Muller detector in a different context. In addition to this, the way the prototype is constructed goes one step further and informs people for the presence of Radiation in everyday life. The overarching goal was to challenge and gather information around peoples' perception of ionizing radiation in everyday life as well as to inform them about its presence.

## Description

The setup is shown in the figures 7, 8 and 9 and it consists of six boxes, each one of them contain an "ionizing radiation source". As radiation sources in this cases are named all the possible materials that could emit ionizing radiation in a certain space. The one used for the setup are air, banana, a faked Cesium's source, soil, fake uranium glass and water. The selection of these samples aimed for covering a spectrum from the background radiation level to a bit more extreme scenarios within the room. It was crafted this way, utilizing a variety of materials representing different levels of radiation exposure,

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<sup>1</sup> The detectors are still an approximation. The idea of approximation should be taken in consideration.

to provide participants with a spectrum of radiation-related sounds, fostering a nuanced understanding of auditory responses to varying radiation levels. For each one of the samples was either used and recorded the sound of Geiger counter detecting the radiation they emit in a period of 15 seconds or it was found online on open source of radiation for the samples we couldn't measure- for safety reasons-. All the emissions were sonified and the samples were displayed on a loop during the performance of the prototype. Eventually the users could access the samples only sonically while the content was remaining hidden. During this process a quiz was developed so the user could guess what was the material based on the audio sample. This addition was implemented in order to collect feedback about peoples' perception for radiation in everyday life. By the end the user could also walk on circular path from the opposite side of the table were the boxes were open and they could have an immediate respond to the actual content of the boxes and matching the audio signal with the actual information. This intervention aimed to investigate how a new auditory element provide insights in humans' perspective, and evoke curiosity for further engagement with this topic.



*Figure 7: Back view of the prototype setting*

## Feedback

By the end of the experiment, the participants were asked for their feedback on the experience. After revealing the purpose of the research in a broader context, the responses from participants provided valuable insights into the connection between sound and attention, surprise, and the effectiveness of information. There was significant interest among participants in interpreting the radiation-related sounds and assessing their accuracy in identifying the materials based on auditory cues alone. After gaining insight from the boxes, they expressed interest in further exploring everyday sources of ionizing radiation. Overall, the feedback could assess the experiment's effectiveness as an educational tool for increasing information and understanding of radiation in everyday life in an engaging manner.

Unfortunately, there was not much fruitful feedback regarding participants' emotional responses to the experiment, such as apprehension or indifference compared to their preconceived notions about radiation. This could be a focal point for discussion and consideration in future explorations.



*Figure 8: Testing the prototype*

## Discussion

Considering the objectives and goals that I had in mind while designing this prototype, and reflecting on it after gathering and processing participants' feedback, there are several conclusions to be pointed out. These conclusions affect and reshape the continuation of the entire research practice. This experiment contributed to the broader exploration of ionizing radiation perception, emphasizing the role and the importance of sound as an element in shaping human understanding. The prototype succeeded some goals in the interplay between perception and response to auditory Stimuli. The findings shed light on how auditory cues related to radiation when they are properly provided to captivate peoples' attention to the sound sensory, induce curiosity. The integration of materials and varying scenarios adds depth to

our comprehension. On the other hand there were several counteracting limitations, negative aspects, and challenges pointed out. The limitations encountered in the process were quite apparent. The auditory experience felt limited, offering not many elements to engage with. The limited number of samples also restricted the phenomenon's representation, as various factors can affect radiation levels, influencing the displayed sources and auditory outputs. Misinformation or the lack of further explanation may have been a challenge. Attempts were made through quiz choices to incorporate similar cases to demonstrate the broad spectrum of radiation levels, but individuals unaware of this may struggle to make connections due to the complexity involved. A further discussion could examine the potential for the experiment to challenge misconceptions about radiation by acknowledging aspects that people tend to avoid. The topic of radiation is often considered taboo in Western societies, leading people to avoid engaging with it or recalling information. Acknowledging and addressing these avoidance tendencies may be crucial in effectively challenging misconceptions.

The last thing I personally feel to address is the insufficiency of the prototype in eliciting emotional and psychological responses connected to radiophobia. Based on this observation that has been a personal struggle, I tried to drive the further experimentation to address this need. This revealed the importance of embodied experience and the usage of the body as a tool to exploring aspects that we cannot perceive. The main topics that I am attracted to figure out are how the embodiment of the experience contributes to overall engagement and learning, but especially how the experience is the suitable mean to fill all the gaps left by logical, realistic,



scientific experiments conducted and ways of thinking applied so far. This relies on Merleau-Ponty's standpoint that perception couldn't be affected by passively received by the brain (perception as data being (Card et al., 1983)), but requires action, where all senses are active, including hearing, smell, and touch. (Svanæs, D. 2013).

However, if we consider the subjectivity of the experience and perception from a phenomenological point of view and compare this theoretical background with the results and the observations after conducting the experiments oriented in the sensory stimuli and straight cognitively processing the information I can criticize that the linkage on perception only through senses and the phenomenology of the body by Merleau-Ponty and especially that the active body and mind as a sensory being is not enough. Thus, I would like to introduce the new materialistic movement and Karen's Barad theory about the agencies and the relationship of beings and the world as a step beyond the thinking so far. Reflecting on the phenomenological explanation of Radiophobia the way of dealing with unperceivable phenomena and cultivating understanding for phenomena that are not tangible lies on provocative theories that overcome the dichotomy of world and body radically.

Based on Karen Barad's perspective two key points frame and discourse my continuation of the practical research, the theory of agential realism and the intra-actions between "atoma". In her theory they doubt about the conventional meanings of matter and agency and propose a non-anthropocentric approach that acknowledges the

entanglement of human and non-human entities. In their concepts, agency is not an inherent property of an individual or human, but a dynamism of forces (Barad, 2007, p. 141). Based on this concept of relationship between different agencies, all designated 'things' are constantly exchanging and diffracting, influencing and working inseparably<sup>2</sup>. This new materialistic approach of thinking I try to embrace in order people to reconsider their relationship and attitude towards agencies that belong to the non-human realm. By reconceptualizing the body as structured through intra-action, a new image of interactive systems and environment emerges. As she says in the book *Agentieller Realismus; "Embracing the fluidity and relationality of material-discursive practices, interaction design can transcend traditional dualisms and embrace a more expansive understanding of embodied cognition."* (Barad, 2007)

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<sup>2</sup> This describes the term intra-action. The Baradian phenomenology enhance connectivity, acknowledgement and respect.

# Chapter 2: Conceptualization of the artefact

The integration of this shifted approach to a prototype lies on emphasizing the subjective experience of individuals, using auditory feedback, that shapes the participants behavior and last but not least, the theoretical principles of new materialism not only by judging the way atoms particles and matter, the separation between humans bodies and environment are already set but also how the performance of the parts of the planet earth and the systems that are beyond our humans senses, understanding and control, nature are not considered enough, in an everyday engagement.

## Components of the main artefact

### Meditation exercises

As already mentioned before the field of interaction design gives a wide range of ways to approach the research topic and effectively designly explore and prototype to challenge people's attitudes and perception.

The possibility of creating a meditation exercise delves from the creation of an experience to the phenomena that humans cannot perceive. The meditation has a fundamental basis on Merleau-Ponty's imagination as the ontological openness of

the body being in the world. The creative operation that yields schema and gives being meaning is an operation of the body in its temporal, spatial, habitual, expressive and intersubjective openness to its world (Flach S., 2013). It was inspired by a similar practice and the text “A kriya for cultivate your inner plant” written by Natasha Mayer that tried to make people sensing Botanica sensoria by imagining and experiencing the functions of the plants. Following the same principles the whole experience aims to familiarize participants with the phenomena, how radiation is produced, what are the different cause, how it participates in phenomena and processes in the atmosphere in order not just to bridge the knowledge gap but also to evoke a more emotional connection and reaction to it, because of the fantasy that not only reproduces what is seen but produces what was never seen before; not imitating but creating a reality (Flach S., 2013).

## Description

The construction of the test was carefully knitted based on the goals for emotional response as well as the wick points of the previous approach and prototypes. The narration is blocked in several small sections/ chapters that tackles a different aspect of the phenomena. Really present is the usage of mental images as imagination and sensation, since all these descriptions of the ability to produce visualized images often point to a distinction between a “self-awareness” and an “attention awareness”. As Gerhard Roth defines:

*“Self-awareness” is the feeling that it is I who does something and experiences something and that I am awake and ‘conscious’,” which is different from an awareness that “concentrates on certain internal and external events, such as percipience, thinking, feeling, remembering or imagining.” In contrast to ‘self-awareness’, “attention-awareness is concentrated upon a certain event, so the more conscious it is.” (Roth G., 2013).*

Most important that there is an introduction and ending paragraph aiming to first disembodied people from how they perceive reality as humans, leave thoughts behind and relax in this journey and the reversed procedure. In order to achieve this an extended description from the human to particles transformation was necessary. Following this the idea of the wave and the energy was introduced to the participants. After that the narration follows all the different types of radiation and complexity behind them in a way that brings people closer to a strange “Other” , that has similarities with a human existence from life to death to interaction, tryouts, different origins, ‘struggles” etc. After gaining a connection with the most abstract and distance information about radiation the story aims to make participants realize that the strange “other” is not so alienated but actually part of the environment and the nature as all the agencies of that sphere are. Scientific terms as pair production, decay, nucleus, atoms, photon, weathering, leaching, cosmic rays and so on are introduced, but the whole style and language of the text is inspired and mimic by Natasha Mayer’s text so it is approachable by people with no previous experience or scientific input. The full text of the Meditation parts could be found attached to the Appendix.

## Feedback

The meditation exercise was tested officially two time and was also distributed to people to practice individually, before the construction of the final artefact. The idea between the different types of tests was to have different types of users, from people with no such experience (amateurs) to professionals, from people with no knowledge about the topic to one's educated in this field. Another test point was if this practice is better to be a group exercise or an individual's personal practice. The last key for the feedback was also the implement of extra sensors and elements outside the narration for immersion or how it would feel to extend this practice to meditative improvisation practice. A detailed analysis according the collected feedback is presented underneath.

Beginning Stillness: *"I started by standing still with closed eyes, indicating a deliberate intention to focus inward and block out external distractions. This set the stage and my state for the introspective journey that follows", "I felt being suspended and flow around", "I was standing still but I felt my body loses balance. In order to keep standing I was drifting from the narration".*

Emptying the Mind: *"I attempted to empty my mind of external thoughts, suggesting a desire to achieve a state of mindfulness and presence. This aligns with traditional meditation practices aimed at quieting the mind and cultivating inner awareness", "for me personally more time was needed to get in the mood and free from other thoughts", "This practice provides a deep insight into the inner workings of the person's mind and body",* Overall, this practice I think provides a rich portrayal of the meditative improvisation practice,

capturing the nuances of both the internal and external journey of self-discovery and expression.”

*Emotional Fluctuations: “I acknowledged the constant flux of feelings and emotions throughout the process. This highlights were the big variability of the human experience and I would say that underscores the deeply personal nature and personal feeling of the practice”, “During the story I felt several different things. In the beginning a feeling of freedom was very present in my inner exploration. I was small and not bound to anything that comes with human’s existence. It was nice. There were though several moments were I felt terrible. Overall I need to admit that I reflected my need and wishes as human in this exploration, where the times I didn’t feel nice it was connected with a realization of things I don’t like in my personal life and experience so far”.*

*Movement Exploration: “Initially, movement does not come naturally, I tried to emphasize the challenge of translating guidance into physical action. However, through gradual exploration and experimentation, movement begins to emerge, starting slowly and building momentum over time”, “In the early stages of the narration I tried to lose my connection with the human body and this didn’t help me to move. I asked myself if I lose myself as what I am going to move.”*

*Physical Limitations: “I reflected on my physical limitations, acknowledging that I may only be able to perform at 50% of my abilities during certain tasks (the fast motion task for example). Despite this, I recognized that giving my best effort in the moment is still meaningful and valuable.”*

*Release and Flow: “I experienced a sense of release and relaxation during the “rain part” of the practice, symbolized by imagining*

*water dripping from the ceiling. This imagery evoked a feeling of surrender and fluidity, leading to movement characterized by flow and simplicity”, “for me the more intense moment of relaxation and release was the ‘rain part’ that forced me to the ground and made me feel heavier”.*

Exploration and Expansion: *“I continued to explore movement, rolling on the ground and finding different ways to navigate the space. This grew a willingness to experiment and push boundaries, ultimately leading to a sense of personal growth and expansion”.*

Desire for Community and Guidance: *“I think that I would love to practice this in a group setting with slow guidance from someone else (you maybe)”, “As a part of a group I would like more instructions and guidance from the instructor”, “It was really hard for me to feel comfortable within the group”, “it was weird because I felt observed by people and this made me uncomfortable especially in the idea of moving in the space”.*

Sensory input: *“I think that an ambient soundscape in the background could enhance the story”, “I would like to have reference sounds in different parts of the narration”, “if there was a moving sound in the space coming from different sources I might move to follow it”, “I would also prefer a dark space with open eyes”, “the physical space around could be shaped as a soft box or with different textiles so there could be a tactile input to explore”.*

## Game construction

As instructor of the meditation exercise and after testing personally a new question arises. How can a design be appealing and acceptable from a diverse audience and



different users? In order to bridge this gap I tried to implement and communicate the whole embodied exploration of perceiving or understanding Ionizing radiation in a different to the previous approaches context. For that reason a gamified exploration was designed where the embodiment was promoted through the participant's engagement with the setup of the game.

## Description

The setup and construction of the game was inspired by Conway's Game of Life. It is a cellular automaton game but not traditional in the sense of having players or objectives, but rather a simulation of cellular automata, which are mathematical models of computation composed of a grid of cells that evolve over discrete time steps based on certain rules. In the Game of Life, the grid consists of cells that can be in one of two states: alive or dead. The state of each cell evolves over time according to a simple rule-set, applied simultaneously to all cells in the grid for each generation. That leads to complex and often unpredictable patterns emerging from simple initial configurations.



*Figure 9: The game of life, analog version in physical space, source: Verena Ziegler*

In my personal interpretation and construction of a game of exploration following the same principles as Conway's Game of Life I was interested in the simplicity of the initial points, where I used only three as the different “origins” of ionizing radiation. The ability of the game to exhibit complex behaviour and patterns helped me to evolve from these three origins to many different aspects of Ionizing radiation such as production of second cosmic radiation, radiation series of elements of Earth such as Uranium and Thorium, fusion and fission, representing mathematical equations, the behaviour of different types of radiation with the matter, characteristics

of radioisotopes such as energy, half-life and yield (possibility of emitting energy) and safety information about shielding. The game is developed in four parts: the beginning, first part, second part and ending. In this game were also implemented cards that provided extra information to bring people closer to the topic of radiation, inform them about and try to clarify misconceptions and introduce a new rule set in the second half of the game set. Participants are taking part in the game as individuals while they are moving around the grid following certain rules. The rule-set for the game depends on each part. For the first part just requires them to move in a specific way- running, jumping, walking- based on the connection within the grid. By the end of this first part and the spot they landed they receive a card as mentioned. This card translate the scientific information to the constrains for each behaviour in the second part of the game. In this one the interactions with the matter described and the sensory input signifies the interaction between participants, grid and rules. The game ends with participant embodying, already from the previous part the different types of radiation and how people can be protected by each one of them.



*Figure 10: Testing the game prototype*

## Dance exploration | Walking exploration

The last years, choreography and dance are becoming established methods of research especially in areas of performance philosophy, dance research, artist research, and performance research, movement and performance are equally, trustworthy for its findings (Merritt, 2015; Welch, 2019). Personally, while working more into the direction of movement as a design research approach and digging into dance exploration several key concepts about dance are grounding each experiment. First acknowledgment according to Fraleigh is that dance is affective, rather than cognitive and the meaning of dance is deeper connected with the expression of feelings. “So while it is a “language”, it is not language. While it “speaks to us”, it cannot tell us. It, “tells a story” but makes no claims.”

Another concept is the embodied metaphor, especially in dance as a lived experience that based on Sheets-Johnstone’s analysis of TIM thinking-involvement relies upon our kinetic bodily logos, meaning that movement provides a ready perceptual kinetic susceptibility for life. “A kinetic intelligence is forging its way in the world, shaping and being shaped by the developing dynamic patterns in which it is living”.

According to this, dancing allows everyone to think in movement instead of using words as an alternative to proceed nonverbal meaning making and communicative action. She also suggests that this is more efficient because it is experienced with the whole body and embodiment is more precise. The term “dance” in this chapter is used to refer

mostly to improvisation. As Sheets-Johnstone's defines improvisation is the exploration and experimental practices of creative movement. Since she argues that through improvisational movement movers are able to access embodied knowledge, movement-knowing, the exercise developed underneath will emphasize this aspect of movement and bodily engagement. Larry Lavender very clearly explains how improvisation can use the embodied action as a kinetic logos and what the importance of it is. *"Improvisation is a way of tapping the stream of the subconscious without intellectual censorship, allowing spontaneous and simultaneous exploring, creating, and performing. Improvisation emerges as an inner-directed movement response to an image, an idea, or a sensory stimulus. Thus, improvisation seems to be an intentional mining of the body using embodied intuition to extract movement-knowing; and the construction and piecing together of movement, shape, and dynamics seem to be an intentional act to execute those findings."* (Lavender L., 2009)

The goal of this exploration using body and dance practice as a medium is to make radiation perceptible in order to change people's perceptions through embodied cognition. Several different exercises, actions and dance prototypes that explore different aspects, and points of view in this unseen phenomena were developed, which are concomitant with Ann Cooper Albright's intimation that improvisation is a "method of inquiry" (Albright 2019, 25). Always a playful atmosphere and an enjoyable involvement were necessary to make the whole topic more approachable.

## Description of each one of them

The speed of light is known to be the fastest in nature and the whole Universe. In this world only the rays can reach this speed, but still there are particles so small in the micro-scale that travel much slower. Imagine that the a particles are so heavy and compact that only travel with 10% while the b particles are thousand times lighter but still can only reach 80% of that speed. But how does it feel to move in this speed? The exercise explores the speed range of individuals and challenge them to behave or move in those different speeds as they were the different types of radiation. How does it feel to be an a-particle or a b-particle or travel as fast as a ray? How an exercise can make us understand the huge difference of those types of radiation, that we usually cluster together as one? These are some questions tackled in a very playful way while bodies and speeds mess in a space.

But exploring the different types and behavior of Ionizing radiation is more than that. This is drawn in the following two exercises that explore how significantly different the interactions between radiation and matter is.

You are heavy and slow but still smooth and penetrating. A thick short line is what left behind for several seconds. Trying to imitate this characteristics of a-particles you have to move on a line across the space, but in slow motion. And with one breath. When no oxygen left there is no more energy and ability to continue further. This translation of constraints of a particles interaction are translating into this physical limitation.

Picture this naughty character as I would describe them. The b particles. They are light and fast, a bit like a small child that doesn't like to obey its parents and is constantly going around.

Excited by everything, moving almost each picosecond in a total different direction. Try to be this particle, to move as fast as the 80% of you maximum speed. And then a clap, a sound that distracts the path. Change direction. Clap again. Change direction. Clap, Change, clap, change...

A really fun exploration, try not to bump to others, try not to slow down, try to concentrate on a clap, to predict the next change. An exercise that drives the attention to something that looks so obvious and simple but could be so hard to achieve and maintain. It aims to make participant explore a total different existence and behavior.

Trying to explore radiation through embodiment opens up a total new world and infinity of possibilities. There are so much things and processes that are involved and worth digging into them and approach them with a new fresh sight. So far I explored the interactions between ionizing radiation and matter but through the lens of the particles.

The following exercise was developed following the same approach as before but adding a new layer of complexity. The bodies are walking around the space either as an a-particle' or as a b-particle or photons as before. But, for now on they have a dual role. They perceive themselves as types of Ionizing radiation but they are perceived by others as a whole atom of matter. The interactions between the participants are very simple everyday life interactions between humans, i.e. eye contact and distance. When they approach each other and manage to see each other in the eyes they need to recreate the impact of this interactions as they were the particles. Change direction and slow down. This interplay between the



participants continues and represent a constant decay, loss of energy, and speed until everything stops.

Another embodied recreation refers to the living cloud chamber. The cloud chamber is a particle detector used for visualizing the passage of ionizing radiation. A cloud chamber consists of a sealed environment containing a supersaturated vapor of alcohol. A particle interacts with the gaseous mixture. The resulting ions act as condensation centers around which a mist-like trail of small droplets form if the gas mixture is at the point of condensation as a visible "cloud" track that persists for several seconds (Gupta, 1946). The last exercise aims to recreate this behavior as people in space are becoming visible inside the "cloud chamber" while acknowledging them the oblique existence of radiation.

## Discussion

After practicing and creating the exercises with different group of people in different settings many interesting points came to the surface.

The main findings for the exercises themselves was around the complication of the structure and the experience of the users. The people that already are practicing dance couldn't face any kind of difficulty to respond to the different tasks and the given instruction were clear and understandable. On the opposite hand participants that had no experience in this approach -dance- demand more clear guidance on the exercises, very specific orders rather than freedom. Most of them suggested to gradually build up the tasks and introduce

the scientific information. Since the exploration requires also the involvement of imagination a special proposal for setting or proposing the imaginative environment was also heard. In the same direction participants that experience both the meditation exercise and the “dance exploration” suggested the application of meditations narrative to create a coherent storyline with the different tasks.

All the things mentioned above where used to finalize and design the proper form of this exploration as well as the way it will be presented in the exhibition setting. The results would be described in detail in the final chapter of the thesis.

## Prototype: Being the radiation source

### Description

A Geiger counter is an electronic instrument used for detecting and measuring ionizing radiation. It detects ionizing radiation such as alpha particles, beta particles, and gamma rays using the ionization effect produced in a Geiger–Müller tube. The ionization is considerably amplified within the tube to produce an easily measured detection pulse, which is fed to the processing and display electronics. There are two types of detected radiation readout: counts and radiation dose. The counts display shows the number of ionizing events detected, displayed either as a count rate, such as "counts per minute" or "counts per second". A Geiger–Müller tube can detect the presence of radiation. There is usually an option to

produce audible clicks representing the number of ionization events detected. The purpose of this is to allow the user to concentrate on manipulation of the instrument while retaining auditory feedback on the radiation rate.

Based on the principle of Geiger counter and the way it detects radiation an immersive recreation was developed in Immersive Art Space (IAS), ZHdK. The main aim was to change the position of how people study and refer to the phenomena. A huge collection of samples that refer to different levels of radiation was gathered. A question on how to prompt this sounds was present. But based on the goal of this experiment, I decided that if I force people to affect the sound output and not the way around this would make a more significant effect perceiving and being aware of the presence of radiation. Taking in advantage the possibilities of technology, and the motion capture system the location and the speed of people in the space were tracked by the system. The density of people and the speed were mapped in the level of radiation and the different samples. By using the MaxMSP software the bodies and their behavior were linked to the audio output. The design of this simple test provide the users the ability to understand the source of radiation and what it means higher and lower level by just being present and a exploring a defined space. In addition the audio output was transmitted in different devices in the space to create the ability to locate the “source” of radiation. Each participant entering the space was also contributed to this composition of Geiger counter output modifying the “radiation-source”.



# Chapter 3: Title of the Artifact: Design Artifact

## Goals and objectives

Going back to the initial point of the thesis project and research I was always driven by the idea of making radiation perceptible by humans in order to broad their perception and attitude towards it, as well as cultivating acceptance and a more open mind thinking to the already existing biases. Drawing inspiration from Timothy Leary's reflections on psychedelic prayers, this design exploration seeks to bridge the gap between the intangible nature of radiation and the human capacity for understanding the unseen.

Since the idea of enhancing human's sensorium and using sensory stimuli as a way to connect was not so fruitful regarding my personal expectations I turned to physicality. Using body as a tool to explore the connection and understanding of complicated and unperceivable phenomena relies on Embodied cognition that emphasizes the role of the body in shaping cognitive processes.

As I mentioned several times through this written text radiation is natural and essential part of our environment. Through my artifact I want to emphasize the inherent beauty found in natural phenomena in order to shift the dominant

narrative that links radiation with danger to appreciate this aspect of natural world and its role. The way to do so is by providing an engaging experience that rescales our existence to another level – the atomic level- and transform and translate this existence in a different ruleset but understand the natural actions we are familiar with as humans could also be present in a different way by a different agent. At the same time, this exploration revealed to me as a different way or path to embrace human's relationship and connection with the "Biosphere", meaning the environment we are part of.

As Susanna Hertrich points out in her work "Manifesto for holistic Complexity" (Hertrich S., 2011) everything in this planet is complex, contradictory and interwoven with everything else and so do people. Driven by this state, on one hand I am trying to make the whole phenomena approachable by a broader audience but this is also combined with approximations, assumptions and simplifications.

The current design practice tries to engage people with the intricate details and broaden their understanding of radiation beyond simplicity by including both imaginative and scientific perspectives, an interference between Ionizing radiation, esotericism, fun and other pseudo or non-scientific fields of knowledge. All this touch upon my personal experience and thinking about dance as the most impactful, in terms of experience, engagement I ever had with my inner self and the surroundings in a really emotional level. Dance is as an extra sense for me that carries all this soft elements and purity that accompany humans. By practicing dance I learned to understand and accept. Start by accepting the self, the failure, the diversity to accept the injustice, the prejustice and learn

how to shift, change and adapt. Is an interesting paradox to lose yourself, detach from the body in order to find yourself and understood the presence as part of a bigger system, of a whole.

Approaching the research topic considering all the above there in constantly present a confusion and uncertainty about the right form, context or constrains to represent this. Admitting the fact that this explorations still seems immature, in terms of time to explore all the possibilities or dive deep in this approach of the ephemeral world, there are several proper or improper ways to communicate the research with broader public and especially in an exhibition setting.

Through the bodily/ dance exploration the main dilemma was about the target group I want to refer to. If I am talking about professional dancers then what is the goal? To propose a different way to explore and find new qualities using as an inspiration radiation? If my goal is to communicate to broader public I could use the dancer as the perfect tool with the best feasibility and create a performance that tells the story to the spectators. But then I realized that this is a misfortune for the audience to passively receive information and miss the whole trip, the personal evolvment and exploration through the body and with the body.

All this thinking doubts, problematizing each representation and constant reflection on the aim of the research, the practice and the interplay between design, artistic perspectives and scientific additions, immersion, sensation lead me to the final proposal for this research to be represented in the exhibition setting and also the possibility for further development. The idea is the construction of a

workshop based on the dance exploration conducted so far. The workshop would be described in detail underneath. However, due to certain issues and imperfections of the workshop that would be presented in the feedback of the user testing, the representation of the research will be conducted via a documentation of this workshop. The documentation prevails to workshop also considering other practical factors.

## Workshop

The workshop gives the opportunity for a broader audience without any previous experience to enter the unperceivable and detached to human senses world of Ionizing radiation. The main reason for such an argument rises from fantasy currently readdressed not only as the ungraspable but also as a complex thinking process that is already embodied. Thus the combination of phenomenology and fantasy, under the auspices of embodiment theories is relevant in understanding complex processes (Flach S., 2011). By defining the workshop as accessible I mean that all the exercises as described before rely on simply everyday movements and can also be adapted in each ones abilities and possibilities. However there is only one prerequisite that is hard to communicate but actually turn to be essential and important. Each individuals willing to abandon their comfort zone and participate in an experimental approach, a bodily exploration that merges with imagination and sometimes interpretation but is strongly connected with informing, communicating and understanding concepts and subatomic physics.



The main inspiration for this workshop and its structure was previous dance workshop I personally took part and others that are really known in the dance community. The workshop “Flying low” by David Zambrano has as the basic idea “dancer’s relationship with the floor but the class utilizes simple movement patterns that involve breathing, speed and the release of energy throughout the body, which explore the primary laws of physics: cohesion and expansion, a connection that I was really interested in. His class begins in stillness in order to connect with the body and with the environment: the air, floor, and the energy of others, forming an interconnection. He afterwards jump to running and passing through each other, running forward backward and around. This structure and development is a feature I tried to adapt for the structure of my own workshop. Another exploration of this workshop that is fascinating refers to the constant spiraling of the body, whether running or standing. These spirals help the dancers into the floor and out of the floor. They already exist and the workshop focuses on finding them. Another interesting element of his workshop is warming all the joints, arms, legs, hands, toes, elbows, feet as extensions of the center to activate the spirals.(Zambrano D., 2009). Another example is the one of Ohad Naharin who channeled his lifelong curiosity about movement into a research roughly developed with friends and family in an experimental, laboratory context. Nowadays Gaga/people classes offer a framework for users to connect to their bodies and imaginations, experience physical sensations, improve their flexibility and stamina, exercise their agility and explosive power, and enjoy the pleasure of movement in a welcoming, accepting atmosphere. The important element of this classes for my workshop is the fact that throughout the

class, participants are guided by a series of evocative instructions deployed to increase awareness of and further amplify sensation. While many instructions are imbued with rich imagery, the research of Gaga is fundamentally physical, insisting on a specific process of embodiment. The last example I was interested in and used as an inspiration is “Fighting Monkey” by Linda Kapetanea and Jozef Fruček, who are professionally involved in art, athletics and movement research and have been developing this practice through a deep study of cross motion analysis, to understand principles of human movement, communication and ageing.



*Figure 11: First testing of the workshop in Cimma Citta. Photo by Claudio Linares Burbat*

Based on the examples described above I tried to frame the workshop and create the proper structure of the exercises. Additionally, I tried for the best logic to create coherence and implement my goals to body involvement. This also is the main differentiation between the workshops I mentioned and mine, that my focus is not the dance technique or skills but communicating and researching ionizing radiation with a body. Thus, throughout the whole workshop I offer pop-up explanations or information section to enhance users' understanding as they interact with the process.

Introduction: The welcoming to the workshop "Embodying Radiation" explains the goals and motives of this workshop and communicate that is a transformative journey where participants are going to explore the essence of ionizing radiation through meditation, movement and dance.

Control of the body\ aware of the body: The initial state of stillness allows participants to center themselves and connect with their surroundings. Through guided meditation, individuals are encouraged to envision themselves as particles, transforming and merging with the energy of the universe. This meditation serves as a preparation and a bridge between the physical and the unseen.

Warm up: From the meditation we transition into physical warm-up, circular movements of the joints initiate a connection with the fundamental forces at play in the subatomic world. Participants engage in fluid motions, rotating toes, ankles, knees, pelvis, arms, shoulders, elbows, wrists, fingers, neck, and head, shifting weight. These circular movements mirror the rotation, the spin and the spiral

movements that can be detected in trace of particles, as dancers become attuned and aware of their own bodies.

Exercises: The workshop progresses to the dance exercises that take place within the space. Participants explore walking, running, and interacting with others. During this exercises guided instructions introduce them to the principles of subatomic physics as well as techniques that are used in dance, such as the different levels and the understanding of the space. Movements may slow down or speed up, mirroring the way particles behave and interact on a microscopic scale as described in detail in the previous chapter.

As the workshop culminates, participants come together to recreate the intricate interactions that occur at the atomic level. Collective movement, bouncing, drop and release evoke the dynamics of this interactions and transformation that reminds more a theatrical scenery a devised theater technique.

Meditation/cool down: Finally, the workshop returns to state of stillness, in a closing meditation. Guided by the facilitator, they visualize the journey of radiation, from its origins in the atmosphere to its role in the processes of the atmosphere, ground, and water. In this moment, participants connect with the profound interconnectedness of all things as Suzanne Hertrich points out in her work “Manifesto for holistic Complexity”, embracing the transformative power of interwoven embodiment- disembodiment and imagination to transcend the boundaries of perception.

The whole structure of the workshop unfolds a story. A personal story. I tried, except the scientific information, to

narrate in different points what fascinated me, point out things I was mesmerized by and made me rethink of the perception of toxicity or risk related phenomena as part of this planet. The above description was defined after several tryouts with people and collecting their feedbacks. Adaptations were made concerning the structure and the logic behind them based mostly on creating this story and offer a journey to this intangible reality. However another realization was the importance of the facilitator and how hard it is to actually conduct this role. The storyboard of the final form of the workshop as well as feedbacks from the participants of the different tryouts are attached in the Appendix.

The workshop conducted five times. After each one of them there was a feedback sessions were participants shared comments on improving the form and coherence of the workshop as well as if they think that the goals of the workshop were achieved. In summary, the table underneath gives a few information about each workshop.

Workshop	Number of participants	Place	Space (aprx.) [m <sup>2</sup> ]
Test 1	5	Outdoor	200
Test 2	3	Outdoor	38
Test 3	5	Outdoor	100
Test 4	8	Indoor	108.6
Test 5	5	Indoor	43.4

*Table 1: Informations regarding the workshop.*

One interesting result was how the amount of people participating affected the flow of the workshop and was affected by each place that the workshop took place. Considering the information above the number of the people should be adjusted to the space since the test #5 worked better than test #3, because for the same amount of people the smaller room was more suitable. Additionally, the number of 8 people in the space of 100 m<sup>2</sup> was interesting that the participants were synchronized.

After all the observations and the feedback received from the participants, and new direction for improvement is the implementation of technology and sound or visual feedback in the exercise to see how this would affect the engagement of the participants and the connection with topic. Specifically, while conducting the last exercise their movement through the space will trigger the sound output of the Geiger counter detector to showcase reveal their presence as radiation. Additionally to the prelist exercise each interaction will generate a visual feedback.

## Teaser and tutorial videos

The documentary reflects the aims and content of the workshop. It introduces the concept of the embodiment and the goal during the workshop to explore the engagement of the body, while providing insights about the connection between dance and science. It is an artistic representation of the basic movement of this workshop, walking, starts with glimpses of the participants and end up to them diving into meditation. From that point the corresponding audio, the narrative begins and follows the participants to the different dance exercises and experience. Finally, the documentary represents the interactions made with bodies while it explores the creative expressions of dancers as they delve into improvised movements inspired by the workshop's themes.

The documentary film is accompanied by a sequence of video tutorials inspired by the work of Mira Hirtz about critical zones addressing that *“This series of video tutorials propose a playful way to deal with some of those questions. It bases on the belief that in order to shift our mindset on how we think about our subjective place on Earth, alternative ways of looking at questions can be helpful. The video tutorials use a performative, playful and somatic approach.* (Hirtz M., 2021). Based on this approach the video tutorials describe in detail each different task of the workshop and helps to the recreation from individuals. It gives instructions from the feeling, aim, tool and examples of people doing each one. They are framed by a suitable title, descriptions and an audio narration.

In the making of those videos from the documentary to the list of the video tutorials, the audio tries to capture the essence of the workshop, since is based on the instructions, descriptions and ambient background soundscape related

with the topic. The use of multiple camera angles is used to convey the energy and flow of movement. The documentary footage is part of the workshop sessions with people that have no experience with the dance approach and short rehearsals, dance exploration and improvisation with experts on the field. The locations that the workshop took place and shots were filmed are diverse from indoor spaces, to outdoor parks and places around the city as well as in Greece with an extreme diverse group of people that blends experts in dance and experts in the field of radiation.



*Figure 12: Second testing of the workshop/Documentation during the process*



The documentary "Embodying Radiation" invites audiences to explore the unseen forces shaping our world, to discover the beauty and complexity of the subatomic realm and the interconnectedness of all things through a captivating mosaic of movement, experimentation, and reflection.

While the audio tutorials encompasses a diverse array of practices bridging dance, art, and holistic approach. At their core, these practices cultivate a heightened awareness of the body, acknowledging that our perception of self is deeply intertwined with other bodies, concepts, and the world around us. The DIY tutorials introduce a fluid, playful, and imaginative nature of practicing and exploring. This playful engagement with perception and bodily awareness extends beyond the self, fostering a deeper understanding and acceptance of phenomena like radiation, often laden with negative connotations. The tutorials, should not be perceived as a prescriptive guide, but as a conduit for shared knowledge. These audios provoke curiosity and experimentation. What if we approached the topic of natural background radiation with this same spirit of playful creativity and rootedness in the body? The instructions to follow, or invitations to engage your perception and bodily wisdom embrace the presence of different beings and forces, like radiation, both within and around us, as sources of inspiration and learning.

## Analysis of the video and the participants' feedback

After conducting and filming the last two workshops apart from the feedback discussions there was an analysis of the videos conducted. Even if the collected feedbacks gave mostly information about the characteristics of the workshop itself as well as its efficiency with the research topic itself the video observation gave extra information about the “untold” comments. Through this analysis, I came to several conclusions about the relationship between the participants, the atmosphere of the workshop and how welcoming it was as well as participants' connection with the research by their bodily engagement.

Some of the most interesting behaviors to observe were:

- Most of the participants in the last workshops chose to be barefoot compared to previous tests.
- The different way that people respond to the narration of the meditation text. The guidance by the facilitator suggested them to explore bodily the text. However, most of the participants immersed in stillness. On the other hand there are different and diverse responses in terms of intensity of the moves as well as different qualities (very fluent, very sharp, guided moves or relaxing to gravity) from different people for the same part of the meditation. Last, there were two participants, who couldn't relax to this process and they were constantly changing position of arms or undergoing gestures that are related to

uncomfortable situations such as crossing the hands or cracking their neck or fingers.

- During the exploration of beta particles, in high speed the participants seemed to have fun with the level of speed that made almost impossible for them to follow and release the difference in the time scale of the “two worlds”, tangible and subatomic.
- The domination of hands, head and legs even if in the first meditation participants were guided to use multiple body parts and break this hierarchy.
- The fact that the participants were synchronized during walking in the space
- Some participants tended to walk in circle around the room and not always make anarchistic choices in terms of directions and paths. Especially when the workshop took place in bigger rooms.
- The necessity, in some cases, for the facilitator to show what was demanded. In the same direction sometimes the participants wouldn't take the initiative to explore on their own if there wasn't a confirmation by the facilitator to do so.
- The presence of jokes for radiation from the participants worked as a beneficial factor to relax, trust the guides and also accept the counterproposal of the workshop compared to radiophobia.
- In the exercise that represent the interactions of the subatomic level it was observed the difficulty to shift from each condition to the new one without stopping while interacting with each other. Thus, a further implementation of a sound feedback to signify the interaction was suggested. It would be interesting to

test how and if the usage of a different medium could affect and resolve this difficulty.

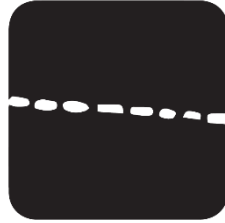
- In the last exercise that tries to represent the cloud chamber the track of the people were defined from the top view camera and each one of those was compared with footage from cloud chamber examples to track if and how the path that the participants are choosing relates to a specific type of radiation.

The most common types are the ones shown in the followings images.

Except from the analysis above and the fact that the feedback sessions where more focused on how to improve the structure and performance of the workshop I conducted interviews with the participants focusing more this time on their whole experience and how the workshop worked as medium in order to communicate the goal of this research. A sample of the interview can be found in the appendix while a summary of the conclusions of it are described in detail in the conclusion part of this thesis.



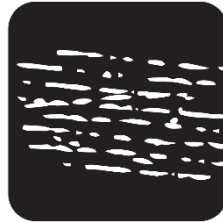
*Figure 13:  $\alpha$  particles traces in Cloud Chamber*



*Figure 15: Meitrons traces in Cloud Chamber*



*Figure 16:  $\beta$  particles traces in Cloud Chamber*



*Figure 14: Gamma rays traces in Cloud Chamber*

After comparing the results I came to the conclusion that there is space for improvement in terms of how people are embodying the traces of radiations types in order to become more aware about the aims of this last exercise. The participants were already familiar with the Cloud chamber's visualizations during the introduction of the workshop but not with the traces of the different types. While this information was mediated through the whole workshop, not visually.

Additionally, the participants that took part multiple times in the end had a significant realization of the purpose of that artefact compared to people that were introduced just once. This, doesn't erase the fact that all participants gain insights about the whole workshop.

# Conclusions

The whole thesis project is aiming to cultivate a different relationship between humans, environment and phenomena that are related to toxicity, through this apply method, the artefact, to practically use the intra action theory by Karen Barad to lead people out of the fear trap, while embracing the unperceivable “universe” and beauty of Ionizing radiation. It achieved in a certain point to make the participants that tried the workshop to re imagine themselves in a different context as a different agent and familiarize them by underlying the constant present of the phenomenon as part of our existence whining the environment even if we don’t cognitive realize it.

The main goal of the artifact is to bridge the gap between tangible reality and what exists beyond that in a dimension we cannot perceive with our immediate sensory input. This also reveals the value of Ionizing radiation as a factor of being, or the existence of the whole world. So this insight works as a counterweight to the negative connotations related to ionizing radiation. As a secondary objective of the workshop I could describe the fact that this workshop tries to make people gain insights in some of the characteristics/ scientific information about Ionizing radiation. The worth of radiation in revealed first through sharing information and familiarize people with the term and subject and Second this parallel the importance of interactions. With this parallel I mean that as for humans is necessary to interact in order to survive, live and exist also in the subatomic scale is also necessary the

interaction in order to exist. However after examining the interviews with the participants all the participants have a very basic familiarity with the term but they never considered the depth of it but still no one had a negative attitude against radiation. However, they found the usage of the body as a medium a very smart choice since is a very powerful tool and also moving is something very common and part of ourselves.

Generally they mentioned that the point of this research project was tackled, they are interested in taking part in the workshop multiple times or even explore extensions of it but they couldn't feel any emotional impact, but a bridge in terms of science and audience as well as communicating complex topics.

Practically, the artefact proves that using the body and the imagination users can be immersed in the narration. By trusting the body-mind being not as a dual dichotomy but as a whole, the workshop unconsciously tried to promote a different attitude a way of thinking us and our surrounding while triggering awareness for the topic of radiation and the fear that is related to it. However, the results of the artefact should be consider not only in the near future but also in depth of time. The present prototype differs from the usual methods that already exist. So far the most present methods to raise awareness are annual reports released by government or the market for people to purchase well enough detectors of radiation for free usage. The artefact brings the existence and the experience in a different scale but it still provides and promotes the idea of living, existing and experiencing both the interaction between the main characters individuals from the tangible reality to the microcosmos. Its aim is shifting



from educating people to simple triggering understanding that the things we cannot perceive, doesn't exist and even more that we all together coexist. It also based on the theory offers a very personal approach and experience, so people can interpret the suggestions of this practice on a very unique individual way.

After conducting and performing the workshop multiple times with different audience another aspect of conclusion and further thoughts opened up. Participants that had already an experience with dance had the best performance and came closer to the ideal response to the workshop as it was design. However the goals were achieved with all the participants. It would be interested to conduct in the future an interview with the different types of participants and actually confirm if the level of performance plays a significant role in the whole process. This would give also quantitate insights about the embodiment. Also, this diversity in terms of participants creates a new approach on how to communicate complex topics to people, based on different that demographically or cultural characteristics and probably promote a more democratic - no hierarchical- communication.

Finally, I could point out that this whole research combines many and diverse fields from philosophy, to physics, to environmental topic, design, embodiment and cognition, which one of those aspects could be studied further in detail. Furthermore, the practical approach and design exploration could also go in a different directions by using different

technological tools and mediums in order to challenge even further the possibilities and incorporate more and more queues of sensory response and the relationship between the different phenomenological perspectives of the different topics that are challenged in this research.

# Appendix

## Disclaimer

For these thesis AI tools were used for different purposes. Mostly, the whole text was prompt for corrections since my English knowledge level is not, as fluent as a native speaker. Another use was to summarize the key points from reference texts. But still the information was compared with personal insights. Additionally, with the text was checked with the relevant tools on web to define the percentage of AI generated text and defined as 3.75%.

The written text is designed and layout in a very simple way in order to emphasize the black pages that appear in certain points throughout the volume. At a first glance it might look random but the sequence of these pages visualize the decay rate of the most common radioisotope that exists naturally in atmosphere, Radon. It's decay follows a log equation that signifies the reduced amount of nucleus through time (in case that we isolate the sample) and especially the moments where the samples activity is reduced in half of the previous state until there are no nucleus left to emit radiation.

For the creation of the audio tutorials was made usage of the EP "Cape", 2023 by the artist Dimitris Mitsiopoulos, <https://open.spotify.com/album/12GPtnU5pjbNfnhW0Q5O40>

Also some sound samples were used from Ambisonic sound library, <https://library.soundfield.com/> . Specifically the following tracks were used:

Crystal Singing Bowls 5 Room B, Richard Devine:  
<https://library.soundfield.com/track/197>

Crystal Singing Bowls 4 Room B, Richard Devine:  
<https://library.soundfield.com/track/196>

Crystal Singing Bowls 3 Room B, Richard Devine:  
<https://library.soundfield.com/track/195>

Crystal Singing Bowls 2 Room A, Richard Devine:  
<https://library.soundfield.com/track/194>

Crystal Singing Bowls 1 Room A, Richard Devine:  
<https://library.soundfield.com/track/193>

## Meditation text

Part I: *“And now you can find a spot in the space that suits you that you feel you belong there and you are comfortable with yourself. Stand tall, and calm. Let the gravity sink your body into the ground below you, and close your eyes. Release any kind of tension and try to let your thoughts escape this room and this period of time. Release your imagination and let it go further than any limitation. There are no more walls or trees or concrete around you. The space transforms to universe. All planets sun and everything in between coexists, from the smallest entity to the biggest. Everything fits in that space. Now imagine yourselves becoming lighter and lighter, so light that you shed the constraints of gravity. You are slowly losing the sense of the ground underneath your feet. You are floating. You are slowly losing the sense of your body parts, your arms, torso and head as you knew it before. You become even lighter, until you transcend the boundaries of shape and dissolve into the vast expanse of the atmosphere. Imagine that your bones are shattered to dust, your skin loses its structure and is not covering the whole body anymore but each one of the little, little pieces of yours. The air is passing through your molecules and you are everywhere, you have become a part of the environment surrounding you. Your journey unfolds everywhere. You are so tiny that you become invisible, attached to other minor elements composing the air around you. You are entangled in the web of natural background radiation. You might be part of a bigger family. That lives as long as Earth does. Born by uranium or thorium, Elements that consist the earth’s*

*crust. You are constantly reproduced because of their journey to stability. An active and alive decay. You can also be individuals, alone in space just as unique components of nature or even man-made, artificial elements released by accident. Or you can be alienated coming from the galaxy, travelling all this miles to end up in the atmosphere. You are cosmic radiation that crossed a rough passage from extreme powers and constant change. As part of that new existence new space, yours space, we are all allowed to start moving. Just because you now know you origin you can start exploring your existence.”*

Part II: *“You can have substance and perceived as matter. But you can also be a wave, energy that travels in space and time in a unique way. As a particle or a photon you discover a unique existence with a lifespan ranging from days to years, experiencing a continuous process of decay, your entire essence emitting energy as you strive towards stability. Close your eyes once more and imagine that the smallest elements of yours in the space interact with everything around them. They give and take energy with atoms protons and electrons. You run and bump to the core of and structure in the space, you bring them in a higher position and activate them to emit energy as you do. You are slowed down by matter across the boundaries of your presence. When you are a particle you have distinct weight and mass. You have the choice to be alpha particles or a beta particles. But not only that’s. When you are a wave, a photon, a gamma ray you are something very different. Picture beta particles a thousand times lighter than the lightest thing of the human world you can recall. This affects how you respond to everything around you. As beta particles you are moving randomly and are halted by a piece of wood... Then, there are gamma rays. You are a wave that composes the electromagnetic fields, traverse through matter, appearing as thin,*

*long lines in your cosmic voyage. But either as a particle or a wave you are not following the time scale that are used as humans. In the realm of picoseconds, a time so fleeting compared to the blink of an eye or the beat of a heart, you traverse space, you interact with everything in your path. Your interactions vary, each encounter shaping your trajectory. As a photon, a wave that carries energy you can have a unique experience. As you twirl and leap, the intensity of your move unveiling the magical act of pair production in the where light transforms into matter and antimatter. Now go back to the particle existence and picture alpha particles the heaviest entities of the dimension you are in. The whole you becomes heavy but still invisible no graspable by human senses. You are a living active weight that acts and interacts. When you affect the matter around you are also affected so much since you lose really quickly your energy, stopped by a mere piece of paper. Imagine all of your interactions as a trace of thick, short lines.”*

Part III: *“Till now you explored not only a different reality but the whole space as well. As the space you are everywhere. Now you can choose a spot in this space, stay close to a wall, or lay on the round, or hug a tree or... Everything you could part of. Be attached to this anchor point in it. Connect yourself physically. Close your eyes and leave behind the universe and zoom out to the bigger scope. Your journey unfolds everywhere, from the vast universe to the troposphere, stratosphere, atmosphere. Earth, soil, water, air, nutrients, plants, human bodies, materials, machines. Attached to dust, ashes, aerosol, or atmospheric or material elements, you are influenced by physical processes, responding to the seasons, solar activity, and Earth's geomagnetic field. You move horizontally and vertically, swayed by atmospheric masses and wind patterns. As the heat rises you start moving more intense. Your activity peaks on warm summer days. On the opposite, you dwindle in the chill of*

*the wind, and responds to humidity. As it becomes cooler that makes you slow, lazy, less motivated, less active less alive. Rain compels you to touch the ground. When drops falling down from the clouds they bumped softly to the elements you are attached to. Since you are so light you cannot resist the weight of the drop and you follow to a downturn. There you experience chemical and mechanical processes. The move of the ground, the flow of the water in soil to streams is drifting you and makes you move with them, travel from place to place, weathering and leaching. And when everything dries, you undergo re-suspension, lifting off again to the atmosphere. An infinity circulation. Of an ubiquitous presence. Now, as you become heavier, imagine you bones are reshaped and your skin doesn't cover each little piece of yours but your human body. The air stops passing through your molecules and you begin to feel the ground beneath your invisible feet, legs, and body. Open your eyes once more, grounding yourself in the tangible reality from which you embarked on this ephemeral journey—a transient existence in the world of ionizing radiation.*

”



## Workshop's storyboard



The participants are standing creating a circle. Welcoming words by the instructor about the duration, the structure and the aim of the workshop.

“This workshop serves as a medium and exploration in order to communicate about complicated unperceivable phenomena as Ionizing Radiation. Since we cannot perceive and the scientific approach is usually unappealing I use the embodiment to contribute to understand, appreciate and accept the coexistence with different agencies of this planet”.



First meditation/ Warming up.

The participants stand as they were before and they are request to close their eyes and immerse themselves in a meditation narration by the instructor.

The meditation tackles the relaxation aims for releasing the imagination and allow an imaginary transformation from human forms to the radiation.

It also introduce the different origins of ionizing radiation.



The participants continue with closed eyes to follow the instruction of the facilitator introducing a physical warm up of the body by starting moving, rotating and connecting with each one of the different parts separately and exploring all the possibilities. From the dominant hands and legs to all the possible joints from neck to spine pelvis.



The exploration of the physical movements of the body continues. The participants still with eyes closed they are guided to imagine thousands of strings attached to their body and they are asked to try to move slowly as their human skeleton was mapped in an abstract form. How could introduce the weirdness and abstraction in the dominant way of moving. How it could be to alienate themselves from the “normal” and try to re-move as something without form.



Spatial exploration of the movements:  
The previous instructions and movement qualities are now extended by the participants in the whole room. “You can open your eyes. The room is now your universe and you are eager to explore every corner of it. As radiation in rotation and twist you move inside and through the space. Each gaps of your thousands of particles are filled with energy and while you move you transfer release and consume energy. Your goal to stability emits the energy you’re filled with.”

Introduction to setting and scenario.



The participants while walking normally they are introduced to the natural background radiation and their activity in so called normality, not dangerous for any specie standards. There are nor a specific galactic event or physical event that affects the amount of radiation in atmosphere as well as no incidents or accidents in the near past.



Minimum speed:

Try to walk as slow as possible. But not stopping imagine that you are walking in-between 2% and 5% of the speed. You can also now starting increasing you speed and go to a normal walking speed.



Maximum speed. Introduction to different types of radiation.

Now let's walk as fast as we can, considering the constrains of the space. The fastest speed ever defined in the space we know is the speed of light. As no present substance, gamma rays you are travelling through universe by following the Speedligh



### B- particles speed:

Now let's reduce to 80% of this maximum speed. As b particles, electrons, the lightest of the lightest thing you could ever imagine you're so fast almost as the light does. But since you have a bit of a mass surrounding that slows you down to this 80%.



### A- Particles speed:

The participants are told to reduce even more to the 10% of their speed range. They introduced to the mass of the a-particles and as being the heaviest presence in the subatomic dimension they are the slowest among the types of radiation.

Then the participants are told to gradually slow down until they finally stop.



## Second Meditation.

Describing the different types of radiation in a more detailed way.  
Transforming to them.

Introducing the timescale of their presence and interaction.



## Exploring a-particles behavior.

As picturing a particles based on the previous description and merging the information about their moving speed the participants are asked to cross the room applying all the characteristics of a particles. Additionally while crossing the space are actually interacting with it. The participants are about to move only as long as they can hold their breaths.

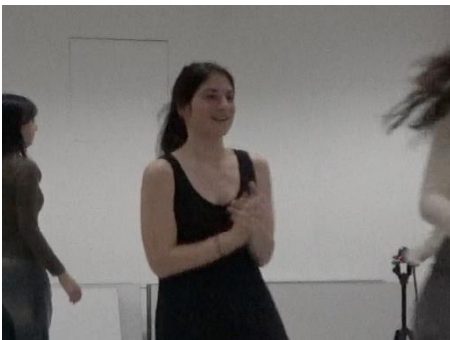


Exploring b- particles behavior.

The participants are gin back to the normal walking around the space.

They increase gradually their speed to 80% and they continue walking trying to maintain and get used to this specific speed.

They are afterwards introduces to characteristics of the behavior of b particles with a familiar analogy.



After letting the participants exploring and embedding this behavior they are introduce to the next task. They are continue walking and change direction every time that a clap sound is produced by the instructor.



### Brehmstrahlung:

The participants are walking back with their normal speed. They choose now between one of those three types of radiation and they embody them. They introduced to their dual role as radiation and as atoms of matter. They interact with each other by conducting eye contact when they are close to each other. This change their direction and their speed to a slower one. When someone loses their whole energy they eventually stop on a spot in the space.



Even in this situation you still need to open your gaze to others. You might not have the energy to move, interact and be affected by others but you still hold your role as atoms of the matter and you can affect the people that are still moving.

The interactions continue until all the participants stop.





### Living cloud chamber.

After reaching stillness the participants are about to create an imaginary rectangle that contains the space in-between them. They are introduced in the function of cloud chamber and they are asked to reproduce it with their presence. They are picking a spot on the borders of this imaginary cloud chamber and they are standing there.

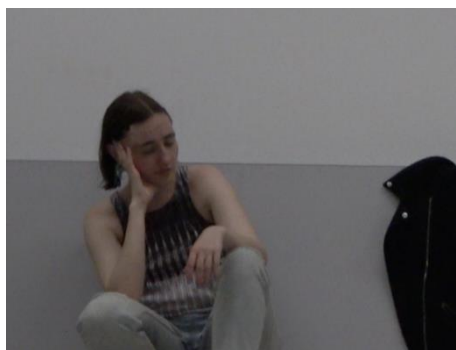


The goal of this task is to just cross the space as fast as they can as high energy waves.



### Cloud chamber (continue):

The goal is to be more than one person crossing the space. Radiation is not something that happens once at a time. The participants are asked to imagine themselves as a particular radioisotope in the atmosphere, not being aware of the other but only concentrate on their decay, their emission, their crossing.



### Final Meditation/ Cool down.

The participants are asked to physically connect with an anchor point in the space. They are closing their eyes and let themselves in the last narration that embrace their constant and oblique presents as well as how they are undergoing a constant circulation through different chemical and physical processing.

Finally, the narration transform them again to the tangible reality that signifies with the opening of the eyes the workshop's end.

## Sample of participant's feedback on the workshop

Test #1:

"it's very important to find a storyline that connects all the exercises."

"I would like to experience different scenography of the workshop."

"I would prefer if the meditation was split in different parts"

Test #2:

"I liked the white walls of the room, were super nice."

"I liked the fact that there was a change between active and relaxing actions. In was also like a reflection period for what happed before."

"The first one meditation was the most crucial. It made me aware of my body and this whole transformation."

Test #3:

"Try to challenge myself to observe or get pushed by you as instructor but then I wasn't feeling I am doing something wrong or I need to see others to evaluate myself."

"I liked the fact that the meditation wasn't about being happy chill and calm but the meditation translated the physicality of the body and the physics of the phenomena."

“ I liked for the last exercise that you mentioned the cloud chamber and showed us in the beginning how it looks like s I knew how to behave and I also felt that it brings all together.”

“I liked the fact that the meditation was in three parts as a circular narration.”

“In the last meditation/ cool down I was destructed by the soundscape. I would like you to talk louder or walk around the people”

Test #4:

“I would like from you to clarify in the beginning that we are able to move freely, to ask questions, to comment, to be more relaxed” .

“When I tried to dance I felt constrained. I didn’t have enough movements.”

“I really like the fact that you were moving while talking.”

Test #5:

“I prefer trying the workshop outside on a park.”

“I, , in the beginning I did the obvious to start moving the arms the easiest to move. But it looks so weird and for me when I afterwards do this with the eyes open I could laugh. It is weird looking and funny.”

## Transcript of the interviews

1.

*Among all of the exercises that we did what was the most difficult for you?*

I feel like the most interesting and difficult it was the one one which we have to move from one point to another mostly because we have also to hold the breath. Also like I remember when we had to move superfast and change direction because it was super hard not to hit other people.

*And what was the easiest for you?*

Oh, the meditation.

*I mean, as you said do you think that the ones that were the most interesting for you were also the exercises you enjoyed the most?*

Ahhhh, yes. Because I had to think more. And this is somehow I enjoyed it.

*And then with which exercise you thought you connected better?*

For your topic? I would say the one we had to start from the corner and then run through the space, But because I had the image of the chamber cloud.

*What was your opinion or your relationship with the topic of Radiation before doing the workshop?*

I knew something like about physics but I always approached it like a very like fearful thing.

*In terms of physics it was like you did in school?*

Yes, exactly. There is something, they explain to you but mostly they are talking about atomic disasters.

*In terms of the information that I gave during the whole workshop, there were things that you knew and things that you didn't?*

Yes, exactly. I knew and I remember some of the things but actually it was interesting because I didn't remember all of the particles and it was explained very clearly and also the thing that we were actually them it very good for learning.

*So if you had to choose between easy, hard, boring, complicated, idk what else how would you describe them?*

I didn't say that is complicated but it is because they are basically. You cannot change them but still they were understandable.

*Alright, so what you think? No. So you think that the way I approached the info in terms of transmitting those information to the participants could bring you closer to understanding? Like what it is being.*

Yes definitely, it was relating to the movement of the people which is something that you usually do, so you understand it.

*And in this section what you thought before while you would consider this information hard?*

Because I always studied and I saw them in like the form of an equation or things like that that is not the easiest thing and also there are many information inside. And something that you cannot see. That is something hard for me.

*So, the whole workshop was basically scientific. But, I tried to bring it in another extension of it. The whole Idea was not just to make it easier to understand but also to try with all these interactions between people to create an emotional impact. Did you had any kinds of emotional, compare to you to other participants*

Ok, So, I had to emotional impact in terms of empathizing with particles. I could relate with the people around me because we were doing the same thing it was somehow like weird, because is something that I usually don't do, so I was empathizing with them but mostly with the radiation when you were describing them as actors, like when they were losing energy and so they move like slower and they are like things like that.

*And the interactions with the other people how did they affect you?*

I mean mostly because I didn't want to hit them. So it's like I was ok.

*So it was a bit uncomfortable in terms of taking care of them?*

Yes, exactly. They were kind like obstacles for me.

*In terms of the impact that you had, basically with everything like the information, the thing that they emotional connection do you think that or how would you perceive doing multiple times the workshop? Because you did it just once. Was it enough for you?*

I would say yes. If I did it more times could affect me differently. I would for sure remember more information and also I would maybe try different like movements. Because I would be like more comfortable, knowing everything. But it

would be also nice to have like different workshops with different kind of adjustments. Not identically the same.

*So, the exercises were approached with to different ways. The one was exploring each type of radiation like more internal, and then I had the other exercises afterwards that were more about the interaction between different elements, matter and radiation.*

*In the first type of exercises, how you could become aware of what you were doing. Was it mostly self driven or you also thought or consider the space around you impacting or defining your actions?*

Well if I understood correctly the question, somehow yes. The place was impacting me but most in the shape and mostly it was about the people how they were also moving. I noticed that at one point I was kind of not following and other times I was following the movement of other people. I think that I am not so aware of the body, so for me it was just about how to move in the space.

If you could realize that these exercises of exploring the speed of a particles and b particles were a different approach towards the last exercises that was mostly about interaction with something outside of it.

Mmm, the two last one they were???? Running and the interaction with others?

Yes.

I would say but is might be wrong that the last ones were much more structured than the first ones.

*About the meditation...*

It's relaxing.



*How you felt about meditation and immersion in the narration?*

Since I don't remember that much about the meditation probably I didn't immersed that much hahaha, but is also because I loose concentration when I am not doing anything. For the meditation I think there was a part where you were like explaining in detail what is happening to the skin or something. It was kind of the beginning? Oh now I remember. For me it was kind of too abstract. So I couldn't relate with that.

*Let's talk a bit more about the last exercise. The one that was very structured and you find it interesting. There was a paradox in a way during the whole workshop. Generally I am trying to promote awareness. With the body, because you have to think what you have to do, with others because you are doing acting together in the same space, for the particles themselves. And then in the last exercise I asked to not to think about the others and act indipendately. Did you find it hard?*

Yes very much to be honest. Hahahahaha. It was very interesting but very hard for me not to think about other people but somehow I felt like I was legitimated to like no care about what was going on around me.

*This exercise supposed to show also the complexity of phenomena in nature, the chaos. It what level you think that this exercise helped you to grasp this complexity, also comparing with the whole workshop.*

For me it was not that much the single exercise but the information that you were saying. Because it s not just like moving around on the space. Is that you have to think that you are like something else.

*And what was your whole impression out of the workshop?*

It was interesting, I mean I was a bit not doubting but usually I don't like this things but it very interesting somehow to learn more about physics in a very different way.

2.

*What in terms of all of the exercises that you did which ones you found difficult? Too fulfill the task...*

I think for the difficulty was when I wasn't feeling comfortable with others. For me because I took part in all of them it wasn't about the task but specific workshop. Because it was very personal.

*And which one you thought as the easiest?*

I thought it was the one that I need to hold the breath and go and of course when it is just slower and walking is easier but also when it was also with strange moves it was also not so weird but I don't know if it is just because I dint stuck, but anyway I felt that it was really fun. Also the one just walking was the easiest.

*Which one you enjoyed the most?*

The a particle or the one running in the cloud chamber.

*And in which one you felt you connected the best in terms of the topic?*

I still believe that it was a particles. I don't know why. It's just such a funny exercise and like very something that I never experienced before. Slowly walking and not breathing. It is so simple and it the same time so magnetic in term of just doing this, so this is what I found very funny and unique.

*Were you familiar with some of the information that I gave during the workshop about radiation?*

I mean, yes. Because I feel like being in science you definitely need to know about radiation and I had physics before. This is why I know but like to realize it from a special point of physics I never knew that it works what is actually happening it took me a while but I understood afterwards I kind get the new information about what is actually happening.

*And what was your opinion about it before, Was it like naïve, neutral?*

Nooo. You know what is the problem from me because radiation is always post to the public. There are no types of radiation. There is just radiation. And when you are bringing ionizing radiation for me was much more concrete and much more related to something scientific. And something scientific for me as a person is much more complex because you kind bringing a very specific type and I was like and this is probably no dangerous. You know for me is when you very much not taking this general context but like very much specific and for me this specificity definitely brings something not scary to this layer of radiation anymore.

*Do you think you could translate or consider this new knowledge in a way , not in the context of the workshop but again like a*

*random moment. Because the info during the workshop is something that is happening all the time. But would you think that you could remember somehow or reflect on this new information or perspective like everyday?*

I think so. This is I feel like I came to this conclusion because at a certain point I started reflecting on what is actually ionizing radiation what it does to atoms, and how they can afterwards realize the chemical reactions and what it is bringing this radical electrons floating around like the whole chemistry. So yeah I felt like I kinda knew it but I never thought about it. And it like I brought tit for me to another layer of what is it actually.

*The whole workshop was like mimicking characteristics of types of radiation to understand the scientific knowledge but they had a parallel role to create somehow an emotional impact on multiple layers. First you and yourself, then with others people around and also with new realization of the topic*

I am not so sure that I had any kinds of emotional connection. like it was not like something alive in terms of relationship. It's more about realizing new stuff and probably emotionally being happy about understanding it but not necessarily emotionally connected to be alpha or beta particles.

*And the interaction with other people, How did this affect you?*

I don't know this is what I mentioned before. Somehow is funny but in a certain way I also need to feel like comfortable

in terms of whom I am interacting and how I am interacting, So for example for the second time, I felt a bit more secure than the first and the third time. But the third time was just funny in general like when this whole atmosphere was releases and as this tough information was decomposed to the funny connection to each other, was much better. So the dimension of the hioumor brought something

*You were one of the people that participated multiple time, how was it for you? Was it boring or each time you discover, thought something new? Could be beneficial?*

I think that meditation, because I am not into it was a bit boring, but in terms of seeing the reaction of different people who were taking part was kind of good for me. I also could have been more relaxed each time.

*There was a different approach from my side to the exercises of let's say first part of the workshop and the second one. Could you recognize this while doing the exercises or was it invisible? or even recall a different impact of the first and the second part of the workshop.*

I feel yeah. It's definitely more clear the first part of the workshop. I mean and also I felt it was for me going it to it probably several times you kind more and more understand.

*During the whole workshop somehow I promote the awareness of the body, the others and the topic itself and also I focused on the interactions while in the last exercise you have to go against all the things I introduced before. Did you consider this? Like, the difficulty of not thinking about others? How was it from this aspect?*

Like in the last part when we are running. Again I was thinking about others just because you still need to be very much aware of them. I mean as well as when you move it's important not to hit people. But this probably would be the only one think that I was thinking about them.

*Also this contradiction tries to introduce also the variety and complexity of nature, the actual chaos haha. Was it somehow obvious through it?*

I think so. But mmm not really. I feel because the exercises are quite similar so I could not see much of a difference between the movement. And I felt like if in this kind terms could be different somehow then probably yes. But as it was now I cannot tell I felt the difference in this specific case.

*Do you think that this complexity of the phenomena it's drawn into that workshop in general? Or the workshop achieves the opposite, simplifying everything.*

I think It simplifies the thing and this is what I liked about it because it's very complicated matter but is not so complicated on how usually people talk about it.

*What impression you got out of the participation to this workshop?*

It is strange. It is like bringing deconstruct everything and understand people by moving of what is it about is still hard. And you kind give us the opportunity of thinking what happening but not necessarily completely understandable, like can relate that you are the particle and what are you supposed to do.

*So you could see this workshop in a school setting explain the physics class?*

Yes definitely. But you know what I am actually thinking? What would be nice if I would see the effects? Because now we are doing this but there is no response. And the immediate response that you talked to me about is probably something that I would like but you know what I would like it much more concrete than abstract. Because for me as being a person from kind of scientific background. So and if you could relate also the impact of radiation. Like hey do you know nitrogen? And how these molecules are connected? And then you dive into radiation. Bringing more concrete examples like result of its existence. Showing what is actually happening and why is it so important in our life. Because it would be something that I could relate. Like exploring from the position of the molecule and explore the whole radiation from another point of view. It would also be technological as you do but also the concrete example could work really nice.

4.

*Which exercise you find the most difficult?*

The most difficult exercise was probably yes the task that we had to hold the breath and try to cross the whole space.

*And which one was the easiest for you?*

The easiest... in the beginning when you just said walk around in the room and imagine the different speeds. Walking slowly, now fast...

*Which one you enjoyed the most?*

When you said, well the task that we had to move from the one point to the other by moving unnaturally, weirdly, this abstract.

*And with which one you thought you connected the most? In terms of the topic*

Actually I think the task we did in the end. That we had the square and then you explained, imagine the video before that this is the particles running around and then when we did this movement exercise I felt like yeah, make sense.

*Were you familiar before doing the workshop and what was your opinion about radiation in general?*

I mean, of course I know but to be honest I have not enough knowledge about it that I can talk about it. I mean, everybody kinda knows that is there but then also I don't really care in my daily life about it.

*Of course I gave too much of information while conducting the workshop in terms also like pointing out the presence but also very scientific stuff. How you found this information itself?*

I think it was not too much to be honest. I think it was good because your topic is very abstract and not so easy to communicate so I think that for me it helped when you were talking and explained in between what we were doing right now or how it is related to the topic and also I feel like there you need to somehow get some background information for the people. Otherwise is super random and then you cannot really relate.

*Could you for example recall this kind of information in a random time?*



Maybe more from the exercises I would remember like because also for my workshop I was thinking to include some movement exercises and how to get people in some state that they are open and then I thought back to your exercises and how you connected movement with the topic of radiation. That was for me more what I took from the workshop.

*So you think that this idea of mimicking somehow characteristics of radiation brought a bit more of understanding?*

It was from a different perspective than. I mean I would never think of a movement point of view about radiation right? And in this context it made so much sense. And it gave me maybe also new understanding of radiation that how can we imagine it, in a way that we can perceive it, because we can't.

*For me these workshop tried through the body and the doing all together exercises not just to bring the same scientific information but also somehow tried to create emotional impact somehow. And then might also create empathy in away with the topic. How you perceived it?*

I think there was not so much empathy maybe not yet. Maybe if we continued to do even more then could be. Is weird how can I connect to radiation but I don't know not so much of emotional impact. Maybe it would have be even more empathy if you think also about how bad radiation is.

*How would you feel if you do the workshop multiple times?*

Yes I think I would do it. Maybe the structure could be the same for every workshop but then maybe there should be

something new or changing and every workshop there is still something special coming up. We could invest more of a time in each exercise because in these you can be quite creative.

*My approach changed from the beginning to the second part of the workshop. The first part was about exploring the types of radiation while the second one was more about radiation in general. Did you realize a shift or something?*

Ah actually now that you mention yes but then I am not so sure I thought about it. But there was the difference that in the beginning we were walking alone around but we ended up in a huge rectangle so yeah.

*Did you think that somehow each part had also a different impact on you?*

I don't think that one part was stronger than the other. I think I general in total was kind of coherent, holistic.

*What about the meditation?*

Haha, I wasn't so focused. This is why don't remember so much about. I mean I also need kind a certain setting to do it, I think for me there was too much distraction.

*During this whole workshop generally there was a tendency from my side to promote awareness. Awareness of the body, of others, of the topic. But in the last exercise I asked you to go against all this notion of being aware of others or think about what others are doing and act super independently. Did you manage? To not consider the others at all?*

Ahhhh hhahha, probably not. I tried I think to just run but. Still of course you are in the same space you see the others. A

first reaction is to look before you start or for me I just don't start like this. First I was looking who was moving but then I thought oh actually I can just go.

*Did you also thought about oh what she told. Did you had any kinds of thoughts like this clash?*

No, because for me made sense that we are independent and they don't decide anything and is a mess.

*That is the goal of the exercise to reveale that is also a chaos. Do you think you could translate or being aware of this complexity also in a different context?*

Yeah, maybe. I mean I am also influenced by my topic soo I think after your workshop and mine I started thinking maybe differently about what happens in nature in general. Because is much more complex and we don't always think it is. I think especially the last exercise revealed that.

And last question, what impression you got out of this workshop in general?

I think like , I really really liked your idea of combining bodily movement with scientific topic to explain some very complex structures with as humans. You don't even need to have anything more than the body. And this was your medium and I found very interesting and I think you could even put this to higher level and make it even more crazy, but of course I liked the idea of immersing with your body and then translating to something else.

5.

*What was the most difficult exercise for you?*

So, for me the most difficult exercise was the one with the b particles, when I have from one hand to think the speed and the changes of the direction but still remembering that my whole body is a b particle so also all the other parts of my body, except legs, had to move with the same high speed as well.

*What was the easiest exercise for you?*

The easiest exercise was when I had to perform a particles, because I had the time to think more things about the movement, cause of the slow speed.

*What you enjoyed the most?*

Although the hard time that I had with the exercise for the b particles, I think that was the most amusing. Maybe because I had to be that child with adhd, HAHA

*With what did you connect the best way?*

With a particles, and that was so , because I could also understand that more.

*What was your opinion about radiation before taking part in this workshop?*

Mixed feelings. Haha, cause of you and due to my studies as well, I already had a good knowledge for the benefits of radiation. So knowing the benefits I can't reject it, but still I am quite cautious, because we know it can be very harmful.

*But did you had any similar input in the past? Did you about those things?*

Yessss I had you

*What was the impressions of the information itself after doing the workshop? Easy? Hard? Boring? Complicated?*

For the first step, was easy to understand it theoretically. Interesting in general. Difficult to process it.

*If the info easy to grasp then could you imagine yourself processing the same information in a random spacetime? Would you actually consider a random day the existence of the other elements of the planet and try to recall the impression of embodying it? Like seeing a world with an extra pair of eyes.*

Hm. In general, in everyday life I don't think that I would do something like that. But I was thinking sometimes, when I was under the sun and feeling the heat on my skin, that it is not only that. And now that I did also the workshop that thought is established and I learned that there is even more and "deeper" layers that we can't recognize, but they exist.

*If the info is hard. What you think made it difficult to grasp?*

I think the hard part is to understand how "big" it is and actually apply that knowledge also in other aspects of our lives.

*Do you think that this mimicking of characteristics of Ionizing radiation could bring you closer to an understanding?*

For sure. Through the exercises we have not only mimicking the particles but trying to be one. That was my point of view at least. I don't know if I am correct. So it was like we tried to increase the empathy for the radiation by get to know it.

*I realize that the workshop is scientific, too scientific but I tried with the approach of the embodiment and these exercise to also bring an extension that could somehow create an emotional impact. (z.B. Eye Contact, smiling,). Did you had any kinds of emotions arising during or after your participation? And if yes which ones. Was it also connected to yourself, to the others and to the topic?*

For me the realization of my feelings is kind hard thing, so I can't really say which feelings I had. For sure especially in the first half of the workshop I felt things or you can say it as I connected with something somehow if it makes sense.

*The interaction with others how did it affect you?*

Xexe, it didn't

*In most of the exercises especially I would mention in the behavior of a particles and the interaction could you re imagine transferring this characteristics to the agency? Do you think that this created empathy for the Particles from your side?*

Absolutely. Trying to act like it make at least to try to understand those particles a little bit more.

*In terms of the relationship that is created between you as a person and the types of radiation do you think that if you would do the same workshop multiple times would this change something about it?*

Yes, though reputation I believe that I could understand the info better and maybe understand also more thing than I have already understand. If you remember the first time I got a feedback it was also helpful to get better to the exercises.

*Generally how would you feel it could help you understand explore find something you? If you do it multiple times? Or one was more than enough?*

I believe doing it multiple time could be more helpful for a better understanding. But also an after workshop conversation would be helpful as well.

*In the first type of exercises (a and b particles) how could you define what is happening to you as a particle for example. Was it driven by the space around you? Were you concentrated on your body itself and your awareness of yourself?*

I think both first meditation and first type of exercises make me think more of my body. Trying my whole body be something else (a or b particle) make me start thinking every part of my body, be more conscious of it, thinking also parts that I don't really put attention to those and move all those "weird" parts to move as something else.

*For meditation I think the success is about immersion. Where you immersed?*

That was also a difficult part. Only meditation didn't really make me immersed. Maybe because movement helps me more for that. To be honest there were some parts, those with the tires that was more helpful to get me immersed.

*What you remember or took out of it? Not just only in terms of the position in the workshop structure but as a whole experience?*

It was more the try to feel my body differently, in ways that I am not used at all and also the difficulty that I find out when I tried to do some of the exercises.

*What impression you got out of this?*

That for things that we know something, we don't know almost anything.



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