



CATÓLICA
ESCOLA DAS ARTES

PORTO

THE SONIC NATURE OF AN EMOTION -
DESIGNING EMOTIONAL
TIMBRE

Dissertação apresentada à Universidade Católica Portuguesa
para obtenção do grau de Mestre em Som e Imagem

Rafael Maia Moreira Ribeiro Ferreira

Porto, Dezembro de 2020



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Trabalho efetuado sob a orientação de
Pedro Duarte Pestana

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Resumo

O objetivo desta dissertação é fazer uma avaliação qualitativa dos vários fenómenos e inter-relações que moldam a nossa relação emocional com o timbre. Ao compreender este fenómeno e o seus contornos, acreditamos que estamos a contribuir para uma maior eficácia na expressão sonora e artística.

Através de uma abordagem baseada na metodologia de Grounded Theory, recolhemos informação em colaboração com um grupo de 12 artistas e profissionais de comprovada relevância na área do design de timbre. Esta abordagem permitiu-nos combinar literatura pré-existente e evidências quantitativas com o conhecimento empírico e qualitativo que estava em falta.

A partir das entrevistas, fomos capazes de identificar os principais fatores que contribuem para a relação emocional do artista com o timbre. Conforme validado pelo grupo de entrevistados, a pesquisa foi guiada pela ideia basilar de que o timbre é uma propriedade sonora que veicula uma grande quantidade de informações sonoras, ou pistas, como lhes chamamos, que completam uma mensagem tímbrica. Sugere-se que essa mensagem tímbrica seja modulada por uma série de paradigmas pessoais e gerais. Esses, que denominamos “Shifting paradigms”, são de carácter social, cultural, geracional e económico. Como estes paradigmas evoluem ao longo do tempo, aqueles que aqui descrevemos, são contemporâneos à era atual.

Contribuímos também com uma contextualização da nossa relação com o timbre em diferentes contextos artísticos. São explicadas as variáveis contextuais das quais nossa percepção do timbre depende e como diferentes contextos artísticos tendem a libertar ou restringir a nossa relação mais visceral com o timbre.

Nesta dissertação, também listaremos uma série de fatores acústicos e psicoacústicos que contribuem para moldar a nossa relação emocional com o timbre. Ao compreender primeiro como o processo cognitivo tende a imprimir o conhecimento inato e adquirido na interpretação de uma mensagem da tímbrica, seremos capazes de preencher a lacuna entre o que é sentido fisicamente e o que é psicologicamente relevante. Isto abre caminho para a exploração prática de fenómenos acústicos e psicoacústicos, como o gesto sonoro, dinâmica tímbrica e exposição temporal, palco sonoro, reverberação e espacialização, destacados nesta investigação como o grupo de aspectos que tem maior influência na percepção da valência emocional do timbre.

Palavras Chave: timbre, emoção, psicoacústica, design de som, grounded theory, arte

Abstract

The goal of this dissertation is to make a qualitative assessment of the various phenomena and interrelationships that shape our emotional connections with timbre. By better understanding this concept and its intricate contours, we believe that we can contribute to the ability of greater effectiveness in sonic and artistic expression.

Through an approach based on the Grounded Theory methodology, we gathered information in collaboration with a group of 12 artists and professionals with proven relevance in the field of timbre design. This approach allowed us to combine pre-existing literature and quantitative evidence with the missing qualitative and empirical knowledge.

From the interviews we were able to identify the key factors contributing to the artist's emotional relationship with timbre. As a result from the practitioners group, the research was guided by the construct that timbre is a sound property that conveys a large amount of sonic information, or clues as we called them, that completes a timbral message. It is suggested that this timbral message is further modulated by a number of personal and general paradigms. These, which we have termed "shifting paradigms," are simultaneously social, cultural, generational, and economic in nature. As these paradigms evolve over time, the ones we focus on are relevant to the present era.

We also contribute with a contextualization of our relationship to timbre in different artistic contexts. The contextual variables on which our perception of timbre depends and how different artistic contexts are prone to liberate or constrain our mostly visceral relationship to timbre are tentatively explained.

In this dissertation we will also list a number of acoustic and psychoacoustic factors that contribute to shape our emotional relationship to timbre. By first understanding how the cognitive process tends to imprint innate and acquired knowledge into the interpretation of a timbral message, we will be able to bridge the gap between what is physically felt and what is psychologically relevant. This paves the way for the practical exploration of acoustic and psychoacoustic phenomena such as sound gesture, timbral dynamics and temporal exposure, soundstage, reverberation and spatialization as the group of aspects that most influence the perception of the emotional valence of timbre.

Keywords: timbre, emotion, psychoacoustics, sound design, grounded theory, art

Content Index

Agradecimientos	iii
Acknowledgments	iii
Resumo	iv
Abstract	v
CHAPTER 1: Introduction and Historic Context	2
1. Introduction	2
1.1 Sound and emotion	2
1.2 Ancient sound design	2
1.3 Timbre pioneers	3
1.4 Emotion	4
1.5 Psychoacoustics	5
1.6 Timbre	5
CHAPTER 2: Literature Review	9
2.1 First scientific proofs	9
2.2 Communicating emotions	9
2.3 Sounding emotional	10
2.4 Designing emotions	11
2.4.1 Sound as an expressive voice	11
2.4.2 Acoustic cues and emotion	15
2.5 Relating features to timbre to practical uses	17
CHAPTER 3: Methodology	18
3.1 Methodology	18
3.1.2 Primary sources	18
CHAPTER 4: THESIS STRUCTURE AND RESULTS	20

4.1 Thesis structure	20
4.2 Results	22
4.2.1 Timbral message	22
4.2.2 Physics	22
4.2.3 The psychoacoustic stage	23
4.3 The shifting paradigms	24
4.3.1 Referencing	25
4.3.2 Timbre and musical genre	26
4.3.3 Culture	27
4.3.4 Generation	27
4.3.5 Socioeconomic	28
4.3.6 Timbre and identity	29
4.4 Timbre, art and context	30
4.4.1 Context dependent variables	33
4.5 Nature and imagination	35
4.6 Gesture	38
4.7 Dynamic relations and temporal exposure	42
4.7.1 Dynamic relations	42
4.7.2 Temporal exposure	44
4.8 Soundstage and Spatialization	46
4.8.1 Soundstage	46
4.8.2 Reverberation	49
4.8.3 Spatialization	53
CHAPTER 5: CONCLUSION AND FUTURE WORK	62
5.1 Conclusion	62

5.2 Future work	66
REFERENCES	68

CHAPTER 1: Introduction and Historic Context

1. Introduction

Timbre is a far-reaching, multi-faceted phenomenon. In this section we explore some loose concepts that will come together in our methodology, introducing timbre from historical, psychological and artistic perspectives.

1.1 Sound and emotion

The relationship between sound and emotion has amazed and haunted us since the very beginning of the human race. According to Charles Darwin's "Evolutionary Theory of Emotion", in (Darwin & Prodger 1998), we might have learned what different scenarios sound like. From danger to comfort, there are sets of acoustic cues that aid as a part of emotion's adaptive role in our evolution. Therefore, it is only natural that sound designers acquired an interest in understanding acoustic patterns that intend to express an emotional idea or state.

1.2 Ancient sound design

The emotional experience that we get from sound has been explored since long ago. In the Peruvian Andes, beneath Chavín de Huántar, a 3000 year old ceremonial center was discovered with a complex underground mind altering maze. These labyrinths were designed to manipulate the sound generated by voice and water within the tunnels to create mystifying effects, its is believed that this experience was even explored in the form of hallucinogenic sessions inside this tunnels and that some men may have not been able to return. (Park, 2016)

Sharon Gerstel, an art history and archaeology professor at UCLA, felt that she was not getting the whole picture when analyzing paintings from the Byzantine era. These paintings were about hymns and hymnographers, nonetheless they were muted because sound is an ephemeral phenomenon. Therefore she tried to understand the sonic feeling and experience represented by the painting with the help of Christos Kyriakakis, the director of the Immersive Audio Laboratory at the University of Southern California. Their findings were incredible. It became apparent that the churches of the Byzantine era were actively designed to give people the ultimate sonic experience. It is now believed that churches were designed in a way that sound would reverberate with a slap

echo effect, and that they called this effect the sound of the Angels' wings. (Standford arts, 2017)

1.3 Timbre pioneers

Edgar Varèse, a French composer that lived the most part of his career in the United States, has a very complete work exploring mainly timbre and rhythm. Varèse and Wen-Chung (1966) proposes a new perspective on how we can compose sound. Varèse saw a world of sounds different in shape and form, he saw his composition free from the constrains of classical composition methods, he heard the faint, but yet enormous potencial of working with the little acoustic aspects of sound. He imagined machines that would be better at interpreting and executing the complex ideias of his inner ear, of his imagination, that would go beyond the melody or rhythm as separated things.

Some say that Varèse is the father of electronic music, because of his support to the introduction of electronic media in the process of making music. This kind of thinking uncovered the potential of “non musical sounds”, noises and different timbres. Edgar Varèse called his music, “*organized sound*”.

He thought of music as “*sound-masses*”, as he called them. He saw music as being tiny sound elements that in the middle of caos, come together in a specific order to form a unique mass, just like de natural process of crystallization, which he used as an analogy to describe this process. As Varèse once said, “to stubbornly conditioned ears, anything new in music has always been called noise”, this led to the question, “what is music but organized noises?” (Varèse & Wen-Chung, 1966)

Inspired by the painter and composer Luigi Russolo, and moved by the same will of sound emancipation as Varèse, is Pierre Schaeffer, a French composer and researcher that stood at the core of the development of “Musique Concrète”. (Schaeffer, 2012) This genre is born out of the necessity to ear the concrete sounds as part of a musical piece. Pierre Schaeffer later on, in a partnership with Pierre Henry, recorded concrete sounds and then used them with other sound sources to create a musical piece. They thought that we should consider a “sound object”, as the primary unit of music. The ideia was that a sound could be recorded and then dissociated from its source and made to have a completely new context. Through processes that altered the acoustic character of sound, such as removing the attack of a violin sound, reversing a choir, or filtering an ambient, Pierre Schaefer and Pierre Henry, created new and unique sound characters that opened up the possibility for an infinite world of timbre exploration.

This “acousmatic” thinking, where the hearing experience is reduced to the sound alone, without seeing its origin, made sound designers want to be experimental. They started

misplacing sounds, mixing them, changing their attack or their tail, removing certain elements; all of a sudden we realize that cracking nuts, twisting asparagus and kicking a football would make for a good hand punch sound for a movie... even though this mixture of sounds is nothing like a real hand punch, it made more sense in conjunction with the picture, it felt more powerful and “gutsy”.

It is this kind of timbre exploration and consolidation, driven by practical empiricism, that may help us find some correlation between what we hear and what we feel.

1.4 Emotion

Emotions play a powerful role in the way we see and perceive the world. Psychology sees emotion as a complex state of feeling that is based on chemical changes in the nervous system which consequently influence thought and behavior. (Cherry, 2020) Strong emotions can even act as a deciding force for one to take action. But what exactly are emotions and why do we have them? Though no consensus has yet been reached in the scientific community, different theories have been advanced by researchers, philosophers, and psychologists over the years. An emotion, much like a sound, is a phenomenon. According to professor David G. Myers, it is a physiological, neurological and cognitive experience, as human emotion involves “(...) physiological arousal, expressive behaviors, and conscious experience.” (Myers, 2004)

Nonetheless, there still is a gap between the process of experiencing a sound and experiencing an emotion, that gap lays on the fact that an emotion reflects an inner state, while a sound, reflects an external physical phenomena. This gap and the correlation between both phenomena is completed (Ferro, 2017) when a cognitive process takes place. Addressing our most visceral selves, the “Evolutionary Theory of Emotion” states that our emotions exist because they serve an adaptive role, as emotions induce reactions to stimuli in the environment, which helps improve the chances of success and survival. On the other hand, one of the best known theory of what is an emotion is the “The James-Lange Theory of Emotion”, suggests that our emotional reaction is the interpretation of the physiological responses to exterior stimuli. (James, 1884) This means that if you encounter a scratching, roaring animal, right in front of you, by instinct the body will start to show signs of fear, the heart starts to race and the hands start to tremble. It is by interpreting this physiological responses and by completing a set of associations and thoughts, that you will be evoking an emotional state, that in this case, is expected to be fear. (Cherry, 2020)

In both cases it becomes apparent that it is by interpreting the exterior stimuli and emotional displays of the surrounding environment, that we can make sense of the world. Therefore, studying the subliminal relations of sound stimuli and perceived

emotion, might reveal patterns for potential new tools for a more efficient emotional sound design.

1.5 Psychoacoustics

Psychoacoustics is the science that relates the measurable physical properties of sound to the human psychological responses to it. Sound starts at a physical level, as waves, coming from vibrating materials, such as a strings on a guitar, or a loudspeaker. It is only when this vibrating waves reach our ears and body that we can sense them, this process is known as the auditory sensation. Nevertheless, the hearing process only is completed when this sensation passes through the brain and our cognitive process that we perceive them as sound. “Sounds are a perceptual experience, and without minds to experience them, there are only vibrating waves.” (Farnell, 2010)

Auditory perception is about interpreting the things we ear, it is the ability to make sense of the information that our auditive senses receive from the environment. This auditory interpretation is an active cognitive process that deals as much with objective internal associations as it is dependent on personal associations and acquired knowledge. Therefore the way our minds process and organize sound is still a very complex and bumpy road for us to be riding in without asking for directions all the time. Some places are still a mystery and others are entirely personal and subjective. Nevertheless, along that road it has been possible to take a glance of some specific psychoacoustic phenomena that are responsible for our relationship with music, language and scene analysis.

The study of these phenomena may enable us to gain a better understanding of the emotional relation with sound that occurs in humans, and those can serve a great use for an effective sound design.

1.6 Timbre

To David Paul Creasey (2006) auditory perception is governed by the intricate interaction of acoustical properties. The broadly considered base elements of sound tend to be loudness, pitch, duration, and "other qualities". Nonetheless, only three of these properties can be measured and compared with accuracy, and yet a sound cannot be fully described without the fourth, referred to as “sound qualities”.

“The complexity of this category is reflected in the lack of a clear definition, and lack of consensus as to what is implied by the fourth major element; even that it is a single major category.” (Creasey, 2006)

The simple task of trying to define timbre becomes harder with every word we write about it - "Talking about timbre, is as delicate as talking about taste." (Manoury, 1991 cited in Smalley, 1994)

Indeed since the early 90s, timbre has been defined more for what it is not, than for what it really is: "That attribute of auditory sensation in terms of which a listener can judge that two sounds similarly presented and having the same loudness and pitch are dissimilar.", as the American National Standards Institute definition for timbre states, brings an interesting point of view as it tries to define timbre for what it is not, rather than for what it is. It leaves an opening to the interpretation that timbre might be everything, other than pitch and loudness. Timbre has been considered such a complex thing that some researchers cannot agree on whether we should study timbre as being completely separated from pitch and loudness or not (Krumhansl, 1989), such is the way it intertwines with every component of what sound is made of. Maybe that is why Claude Cadoz (1991) goes to say that any discussion about timbre is capable of shaking with the very nature of music itself.

Krumhansl (1989) exposes a few problems with the ANSI definition of timbre and one of them is exactly the negativity associated to this definition. She notices that that this definition originated in the context of traditional musical instruments, therefore it is only concerned with the differences between acoustic sound sources, yet the reality of designing sound nowadays goes far beyond. Furthermore, defining timbre for what it is not, "leaves no scope for the analysis or measurement of timbre in terms of its inherent features."

Nonetheless, in another perspective, should we be so naive as to believe that we can grasp in a matter of numbers what has been one of the most complex, mysterious and non-consensual properties of sound so far? The book "Le Timbre: Métaphore pour la composition.", Jean-Baptiste Barrière (1991) finds in timbre "the inevitable breaking-point of every musical discussion and every compositional confrontation."

Maybe the problem is that we still do not know how to talk about timbre. Its historical DNA anchors on an old idea of organization of distinct sound categories and their relations, rather than focusing on the inherent sound characteristics. In Western tonal composition the timbre of a sound has been conceived as a simplistic view of the type of sound (e.g. instrumentation), (Sean Soraghan, 2018), a notion that is now far behind, once the introduction of electronic means into the sonic world, brought the active use of both big and minute variations of timbre parameters and this process has become a very important compositional tool. (Gomes, personal communication, 2020). We can think of the example of electroacoustic music, which utilizes timbre and timbre variation as one of the most fundamental tools in the composition process, this creates infinite timbral

possibilities, allowing the process of designing sound to be free from the constraints of source and matter driven sounds, this way enabling for new, more abstract and imagination driven sonic results. In electroacoustic music, sound sources may be “(...) varied, evident or ambiguous, actual or implied, unknown or unknowable: we can perhaps detect traces of cause or source but realize that neither can exist in reality.” (Emmerson, 2019) This means that, unlike instrumental and vocal music, in which the sources are known and relatable, electroacoustic music can be a compositional exercise full of shadings and psychoacoustic interactions of completely abstract sounds that may or may not be unveiled and comprehended by the listener. “One of the great interests in electroacoustic music is the adventure of bonding play, which I regard as an inherent perceptual activity.” (Emmerson, 2019)

“Within the field of electroacoustic music, multiple examples of graphical scoring techniques have been developed that constitute methods of perceptual timbre representation from an abstract, subjective (rather than data-driven and objective) perspective.” (Sean Soraghan, 2018)

Many attempts were made to try and concretize a common language with which we could approach electroacoustic music and its spectral and timbral complexity. After Pierre Schaeffer’s first solid explorations to describe “concrete musique” in *Traité des objets musicaux*, (1966) and *Solfège de l’objet sonore*, (1967), multidimensionality was advanced by Lelio Camilleri which had its bases set on frequency, dynamics, spatiality, syntax and phenomenology. (Tanzi, 2011)

Nevertheless, “in the field of analysis, Denis Smalley’s spectromorphology has been holding its merit in offering technical vocabulary and methodology for the description of sound forms and sensations in acousmatic sound experiences.” (Blackburn, 2011 p. 5).

These attempts to describe a spectral evolution and the inherent interaction with other dimensions of sound like dynamics, spatiality, syntax and even phenomenology, are proof that timbre is a multidimensional quality of sound and it sits right in between what is acoustically happening and what is psychoacoustically pertinent. It is about the multiple variables and dimensions that are involved and the details that our ears cannot separate but still are sensible to their every minor behavioral changes. (Smalley, 2009)

Therefore, a timbre definition that embraces all these attributes and nuances in a contemporary perspective is needed. As proposed in Simon Emmerson’s “Timbre Composition in Electroacoustic Music” (2019), a more adequate approach to the definition for today's times might be taken from adapting a former definition by Michel

Chion: “Timbre is a general, sonic physiognomy through which we identify sounds as emanating from a source, whether that source be actual, inferred or imagined.”

CHAPTER 2: Literature Review

2.1 First scientific proofs

There is evidence of scientific attention to the peculiar relation between sound and emotion starting in Scherer and Oshinsky (1977). In their “Cue Utilization in Emotion Attribution from Auditory Stimuli” study, the authors undertook an experiment that strived to understand whether the manipulation of a sound’s acoustic character would affect the emotion attribution by human judges. They used synthesised sounds that would vary their acoustic character, or as they called it, their acoustic cues. This systematic variation of acoustic features, such as amplitude and pitch, pitch level and contour, tempo, envelope and filtering, led to the strong confirmation that there is a latent correlation in the variations of these parameters and the attribution of emotional value by human judges. Although this study could not specify the particular patterns of each acoustic cue that led to the attribution of an emotion, they were able to observe strong evidence of the existence of systematic effects due to parameter manipulation.

This sensory phenomenon might seem a bit strange at first, but let’s take a step back. Above, we discussed how we communicate with our ears, and how auditory perception allows us to understand the world and our fellow human beings. Is it not true that we can perceive if a person is sad, or angry, or happy when we are having a conversation with them? For most humans this is a natural talent and needs no further thought (Adelino, 2017). This corroborates the idea that there are voice acoustic cues which reliably convey the vocal expression of particular emotional states and that listeners are able to accurately identify the emotional state of a speaker on the basis of such vocal cues, as initially proposed by Scherer and Oshinsky (1977)

2.2 Communicating emotions

As it is so tied with principles of human interaction, communicating emotions is very important for us humans, in order to understand and be understood by the world, to undertake social relationships and promote survival skills. (Ekman, 1992)

This type of communication is also a very important part of our culture. Communicating emotions is a constituent part of performing arts, such as theater and music. (Wilson, 2002) In the performing arts particularly, there is a proximity to the audience, there is a latent intention to connect with those that are watching you and vice-versa, and it is often desired or expected that there is an emotional engagement between both. (Lima, personal communication, 2020; Martins, personal communication, 2020)

2.3 Sounding emotional

Two of the most expressive and effective means of emotional communication are vocal and musical expression. Both are nonverbal means that rely on acoustic signals and variations for the transmission of messages. (Juslin & Laukka, 2003). There is a long line of researchers that have been proposing theories about a correlation between vocal expression and music. (Juslin & Laukka, 2003)

Spencer as cited in (Juslin & Laukka, 2003), believed that vocal music and instrumental music are closely related when it comes to expressing emotions. He formed a theory that is based on physiological aspects and in which he reminds us the general law that feeling acts as stimuli to muscular action. This means that emotions can influence physiological processes which in turn will stimulate muscular action, consequently influencing the acoustic characteristics of the vocal expression. This concept, frequently referred as Spencer's law, is often ground for the attempts to explain similarities between vocal expression and music. (Juslin & Laukka, 2003)

If we really think about this, it is easy to understand why this phenomenon would happen. As humans, we tend to exteriorize our feelings when we want to communicate. That is how we give others a chance to understand us, and we tend to do that also with our physicality. In fact many actors and performers use techniques such as the "emotion memory" from Stanislavsky's method, in order to express an accurate emotion to the audience. The method, loosely consists in evoking the memory of the state ones's mind and body were in, when feeling a determined emotion, as well as the physiological associations and realizations which will then express the emotional state to the audience. (Stanislavski, 1991)

"Many physiological changes influence aspects of voice production, such as respiration, vocal fold vibration, and articulation, in well differentiated ways. For instance, anger yields increased tension in the laryngeal musculature coupled with increased subglottal air pressure. This changes the production of sound at the glottis and hence changes the timbre of the voice" (Johnstone & Scherer, 2000 cited in Juslin & Laukka 2003, p. 773)

The ideas above seem to indicate that there is a close relationship between emotion and physical act, which in turn will mould the character of a vocal communication. In addition, there are also neuropsychological studies that further support this idea. Researches seem to indicate that some aspects of music, "such as timbre, share the same neural resources as speech, whereas others (e.g., tonality) draw on resources that are unique to music." (Patel & Peretz, 1997; Peretz, 2002 cited in Juslin & Laukka 2003 p. 774)

In a neurophysiological research on musical timbre (Goydke et al., 2004), it was shown that the same melody played with different emotions (happiness and sadness) or instruments (violin or flute) generates mismatch negativity (MMN) i.e., a brain response to violations in a constant, (Garrido et al., 2009) this way confirming that the brain is sensitive to both emotional and timbral variations in music. If so, it is arguably easy to understand that multidisciplinary studies have been repeatedly mentioning timbre and acoustic character as being among the most influential and active characteristics of sound on the way we recognise emotion through auditory perception. (Juslin & Laukka 2003)

2.4 Designing emotions

From this point on, we can start thinking about how we, as composers, sound designers and sound professionals, have been appropriating from these characteristics over the time to be able to tell stories and make people go on a sensory journey with sound and music. As it is recognizable that music evolves from a means of emotion sharing and communication to an art form with its own rules, (Juslin & Laukka 2003) we should start by briefly analyzing how we have been using timbre in the sonic arts to convey an emotional idea and go from there;

Evidence has been found that listeners can accurately categorize songs that express different emotional states such as festive, mourning, war, lullabies that come from different cultures (Eggebrecht, 1983 cited in Juslin & Laukka, 2003) and that these songs share certain acoustic cues; for mourning songs a slow tempo, low sound level, and soft timbre, are characteristic whereas festive songs call upon fast tempo, high sound level, and bright timbre (Eibl-Eibesfeldt, 1989, cited in Juslin & Laukka, 2003)

This means that in general, human listeners are able to perceive different emotional states from different songs across different cultures, and one of the characteristics that allows listeners to accurately categorize them by emotional type, is timbre. Timbre will give the listener a clue of what emotion that song is trying to express. Have you ever wondered why do we associate more easily a mellow violin to a scene of love rather than a distorted guitar?

2.4.1 Sound as an expressive voice

Juslin (2004) ventured to say that what makes a violin performance so expressive is the possibility that it resembles the human voice while going surpassing what human voice capabilities, in terms of speed, pitch range, and timbre. Consequently, it is reasonable to speculate that musical instruments are processed by brain modules as super expressive voices. (Juslin & Laukka, 2003) “For instance, if human speech is perceived as angry

Emotion	Acoustic cues (vocal expression/music performance)
Anger	Fast speech rate/tempo, high voice intensity/sound level, much voice intensity/sound level variability, much high-frequency energy, high F0/pitch level, much F0/pitch variability, rising F0/pitch contour, fast voice onsets/tone attacks, and microstructural irregularity
Fear	Fast speech rate/tempo, low voice intensity/sound level (except in panic fear), much voice intensity/sound level variability, little high-frequency energy, high F0/pitch level, little F0/pitch variability, rising F0/pitch contour, and a lot of microstructural irregularity
Happiness	Fast speech rate/tempo, medium–high voice intensity/sound level, medium high-frequency energy, high F0/pitch level, much F0/pitch variability, rising F0/pitch contour, fast voice onsets/tone attacks, and very little microstructural regularity
Sadness	Slow speech rate/tempo, low voice intensity/sound level, little voice intensity/sound level variability, little high-frequency energy, low F0/pitch level, little F0/pitch variability, falling F0/pitch contour, slow voice onsets/tone attacks, and microstructural irregularity
Tenderness	Slow speech rate/tempo, low voice intensity/sound level, little voice intensity/sound level variability, little high-frequency energy, low F0/pitch level, little F0/pitch variability, falling F0/pitch contours, slow voice onsets/tone attacks, and microstructural regularity

Note. F0 = fundamental frequency.

Note. Taken from “Communication of emotions in vocal expression and music performance: Different channels, same code?” by Juslin, P. N., & Laukka, P. (2003). *Psychological bulletin*, 129(5), p. 802.

when it has fast rate, loud intensity, and harsh timbre, a musical instrument might sound extremely angry in virtue of its even higher speed, louder intensity, and harsher timbre.” (Juslin & Laukka, 2003 p. 803) The emotion perception module of the brain is triggered by the music’s voice-like nature, then the listener picks up on the super expressive contours abled by this voice. (Juslin & Laukka, 2003) Even so, it has been pointed that the emotions evoked in listeners may not necessarily correspond to those expressed by the performer, nonetheless they are presumed to be empathic or complementary (Juslin & Zentner, 2001 cited in Juslin & Laukka, 2003).

Returning to why it is easier to associate a mellow violin to a scene of love rather than a distorted guitar, it is safe to assume that it might be related to the voice-like nature part of the sound of the instrument, where the acoustic characteristics of, for example, the violin or the saxophone, are able to closely relate to the sweetness that we tend to imprint in our voice in a romantic situation, rather than an angry distorted guitar that would much easier relate to the roughness and harshness latent in an angry scream.

Juslin and Laukka (2003) point to redundancy among acoustic cues as an evidence of such intercorrelations, which reflect the sound production mechanisms of the voice and of musical instruments. “For instance, an increase in subglottal pressure (i.e., the air pressure in the lungs driving the speech) increases not only the intensity but also the

fundamental frequency F0 to some degree. Similarly, a harder string attack produces a tone that is both louder and sharper in timbre” (Juslin & Laukka, 2003 p. 802)

In table 11, we can see a summary of the patterns of acoustic cues that correlate with emotions suggested by Juslin and Laukka (2003), and it is fairly easy to relate those of anger, with a distorted guitar (i.e., high sound level, much high-frequency level, high F0 level, etc.). In the same perspective, it becomes even easier to relate the tenderness of the violin to acoustic cues like (little high-frequency energy, low F0 level, slow voice attack, etc.).

This knowledge brings us some new and insightful perspectives to how we can increase the emotional expressiveness of our sound works. Author Patrik Juslin has often defended that instruments can be processed by the brain as super expressive voices, with super expressive parameters that we can manipulate, such as tempo, intensity and timbre. But let us keep focus on timbre, despite its proved importance, timbre is one of the most under looked capabilities of sound, much less than pitch, intensity and duration (Holmes, 2012; Eerola et al., 2012), and has only now, in this century, taken its place as an element of music and sound worth to be further explored. (Liu et al., 2018)

Recent studies, have recognized timbre as being more immediate to the recognition of emotion than other music cues, which tend to take longer to be processed (Eerola et al., 2012), “as evidenced from the findings that listeners could distinguish emotion categories based on very short musical excerpts” (e.g., Peretz et al., 1998; Bigand et al., 2005; Krumhansl, 2010 cited in Liu et al., 2018). This interest in the exploration of timbre and timbre parameters that can be manipulated has been reflected in the new and innovative brands of analog and digital synthesizers that have been growing exponentially over this decade together with their knowledge, building upon the first Robert Moog synthesizers, with a whole lot of new and creative ways to perform several parameters of timbre with high levels of expressiveness.

Juslin and Laukka (2003) found studies that widely validate that emotions can be communicated successfully on different instruments that dispose different acoustic cues to the performer. “(If a performer cannot vary the timbre to express anger, he or she compensates this by varying the loudness even more.)” (Juslin & Laukka, 2003 p. 802). What this means is that when a sound is played, the little or big variances it has in its timbre/acoustic character will add as an expressive clue for the listener to be able to understand the emotion conveyed by the musician/performer.

As we saw above in Juslin’s “super expressive voice” concept, the listener would have his emotion perception system further aroused by such timbre parameters that have “extra-vocal” characteristics. These capabilities in instruments have caught our

attention, for they can be an even more powerful set of clues in conveying emotion than the voice like nature of the sound itself. For all we know, from Juslin theory, the emotion perception module is gripped by the voice like nature of the sound, but it is the “extra-voice” capabilities of the instruments that make them, “super expressive”. It is thus safe to say that timbre plays a very important role in music construction (Menon et al., 2002), given the fact that most composers rely on instrumentation, that is, the selection of different sounds to depict the emotion underlying in their music (Schutz et al., 2008). In fact Menon et al., (2002), refers to timbre as a “major structuring force in music and one of the most important and ecologically relevant features of auditory events.”

Being that as it is, it might be worth taking a look at what parameters could be used or performed to explore this super expressiveness latent in the timbre itself.

There are only a few studies that are able to unveil what parameters could be used or performed to explore this super expressiveness to a desirable level of accuracy, yet they tend to be fairly consensual across most researchers. In a work by Hailstone et al. (2009), the authors argue that the interaction between perceived emotion and timbre “does not depend simply on lower level acoustic or structural factors nor on the individual's past experience of music, but is a robust effect driven directly by changes in timbral characteristics such as attack and spectral content.”, thus agreeing with some of the findings in older studies on polyphonic timbre, (i.e. the timbre of more than one instrument), where it was shown that the arousal dimension of emotion is solidly correlated with the high-low frequency energy ratio of spectrums. (e.g., Alluri & Toiviainen, 2010).

In an extended study of the timbre of only one instrument, Eerola et al., (2012) made an investigation about emotional connotations of isolated instrument sounds, through a series of perception experiments. In these experiments the authors found that the affective dimensions of arousal and valence of the sound, were mainly determined by “spectral (high-low frequency ratio), temporal (attack slope, i.e., the slope of the period in which the sound changes in intensity before reaching its steady-state) and spectro-temporal (spectral flux, i.e., an acoustic feature measuring the speed of change of a signal's power spectrum) parameters.” (Liu et al., 2018 p. 2)

Both studies show that high-low frequency ratio of the spectrum might be one of the most important parameters in this relationship between timbre and emotion perception, nevertheless, Eerola et al., (2012) introduced new parameters such as, temporal (attack slope) and spectro-temporal (spectral flux) and found them to actively affect emotion perception. Later, Wu et al., (2014) worked on the problem of identifying the most salient timbral features in sustained musical instruments after equalising for attack time

and spectral centroid, and came to results that are consistent with Eerola's Valence-Arousal ones.

All these investigations seem to confirm that “musical instrument timbre [will] carry cues about emotional expression that are easily and consistently recognized by listeners.” (Wu et al., 2014 p. 931) Although there seems to be consensus in identifying spectral centroid/brightness as a significant component in music emotion, Wu et al., (2014) further notices that even/odd harmonic ratio is the most salient timbral feature after attack time and brightness have been equalized. (Wu et al., 2014)

2.4.2 Acoustic cues and emotion

These recent studies are particularly interesting because they brought palpable evidence in a world that is quite abstract in itself as is the sound, especially the timbre.

What I mean with this, is that, as sound designers and composers, it is more interesting and applicable to work with parameters that we can actually manipulate and perform. Timbre is by itself and by definition difficult to grasp, working with it and manipulating it, can be a very abstract task, but if we are able to understand patterns in the controllable parameters we have at the tip of our hands, as in a synthesizer for example, it might be easier to convey emotions with timbre. As Pardo et al., (2019) notice, though, the use of low-level parameters as controls asks for deep knowledge by an end-user and there is a semantic gap between how we talk about what we wish to manipulate and the features that allow this manipulation.

Hailstone et al., (2009) and Liu et al., (2018) work might help in doing just that. The first research aimed to understand the relation between the instrument identity and the emotional information that this conveys. The second was focused on understanding the emotional connotations of musical timbre of isolated instrument sounds based on the emotional speech prosody.

In Hailstone et al., (2009), the authors used four novel melodies played with new and experimental timbre designs, where specific timbral cues to particular emotions were incorporated. They created four new timbres based on spectral content and temporal envelope related features, as shown in table 3. The authors concluded that “the novel timbres 1 and 3 (Table 3) incorporated properties including high energy at lower harmonics (conveying a “dull” quality), slower attack, and slow vibrato, which have been associated with sadness, while Timbres 2 and 4 incorporated properties including higher energy at higher harmonics, “notched” spectra (conveying a bright or “brash” quality), and more rapid attack, which have been associated with anger or happiness, and rapid vibrato, which has been associated with anger and fear. [...] Anger was better identified using Timbres 2 and 4 than using Timbres 1 and 3, while, conversely, sadness

was better identified using Timbres 1 and 3 than using Timbres 2 and 4.” (Hailstone et al., 2009)

<i>Timbral property</i>	<i>Timbre</i>			
	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>
Spectral content	Strong middle and low frequencies.	Strong high frequencies.	Strong low frequencies.	Few harmonics, “notched” spectral envelope.
Temporal envelope	Slow attack and decay.	Fast attack, slow decay.	Slow attack, fast decay.	Fast attack and decay.
Vibrato rate and depth	None.	Fast and mid amplitude.	Slow and low amplitude.	Fast and high amplitude.

Taken from “It's not what you play, it's how you play it: Timbre affects perception of emotion in music.” By Hailstone, J. C., Omar, R., Henley, S. M., Frost, C., Kenward, M. G., & Warren, J. D. (2009). *Quarterly journal of experimental psychology*, 62(11), 2141-2155. p. 2150

Similarly, in the second research, (Liu et al., 2018) the authors carried out an experiment that was focused on understanding the auditory properties that carry emotional meanings in both music and speech for three basic emotions, anger, happiness, and sadness.

In this experiment, the researchers concluded that angry instruments and angry speech were characterized by acoustic features that indicate a “rough sound quality (e.g., higher attack slope and spectral centroid, higher ratio of high/low frequency energy, and lower spectral flux than those of happiness) while happy instruments and happy speech were characterized by features suggesting a pure-tone like sound quality (e.g., lower attack slope and spectral centroid, lower ratio of high/low frequency energy, and higher spectral flux than those of anger). Compared to happiness, anger has a higher attack slope which means a faster rise to its peak intensity, suggesting that the full volume of angry sounds is reached within a shorter time than that of happy sounds.” (Liu et al., 2018 p. 7)

With regard to sadness, there are two kinds of sadness: grieving sadness and depressed sadness (Xu et al., 2013).

In this experiment, evidence confirms that depressed sadness is usually characterized by low amount of high spectral energy which means lower high–low frequency ratios and spectral centroid, whereas grieving sadness as reflected the opposite.

This study is the first to provide empirical evidence that musical timbre could trigger emotional connotations similarly to speech. Further supporting the notion that timbre is an instrumental tool for composers to design the emotional contours of music, just as humans use voice to communicate emotions. (Liu et al., 2018)

2.5 Relating features to timbre to practical uses

The previous discussion begged for additional information on how practitioners that deal with timbre in their fields (composers, sound designers, sound engineers) establish relationships between their sonic manipulation strategies and the resulting emotional impact of the sound that is created. This can be looked at from a Grounded Theory (Glaser et al., 1968) perspective if one is to understand how practical knowledge emerges on a field, or from a Knowledge Engineering (Studer et al., 1998) perspective if one is to apply it in tools that are then to be used by practitioners. Few thorough research has been used with these methodologies in mind when dealing with the subject of timbre, with the exception of Holmes (2012), a study in which timbre is explored as an inspirational tool and as a leading performance tool for the communication of emotional intentions, based on the empirical knowledge of a single elite musician.

CHAPTER 3: Methodology

3.1 Methodology

The main methodology used in this research is based on the Grounded Theory approach, as this strategy investigates the qualitative aspects of how and why a determined phenomenon occurs by learning from the way people experience and perceive it. (Polkinghorne, 2005 cited in Mohajan, 2018)

According to Creswell (2009), this strategy often used in social sciences, involves the collection of qualitative analysis data from a focus group specifically chosen for its professional relationship and relevance in the field of study. This process of collecting data from individual interviews with the members of the focus group, will result in the interrelation and association of data in several stages, (Charmaz, 2006; Strauss & Corbin, 1990, 1998), further allowing the application of inductive reasoning, i.e., from learning and observing on primary sources, we will be able to create a set of hypotheses that compare with pre-existing evidences. (Rainbolt et al., 2014)

3.1.2 Primary sources

For the purpose of building a more comprehensive knowledge across all of the timbral attributes that correlate with emotion perception and understand the way it works in a practice based point of view, a number of individual interviews were conducted with a group of 12 renowned artists and professionals that have very prominent concerns about timbre in their work. The choice of this set of professionals was designed to have a broad range of different areas of expertise, i.e., composers and sound designers that work from theatre, to dance, to cinema to sound art installations, etc., thus looking for any common practices and concerns on timbre designing in the different areas.

This group of 12 artists/professionals consists of Pedro Marques, a soundtrack composer for movies and video; José Alberto Gomes, a well know composer dedicated to timbre exploration ; Vasco Carvalho, a sound editor, designer and mixer for cinema; Rui Lima and Sergio Martins, probably the most famous composers for performative arts in Porto with award winning shows and over 100 soundtracks made; Gustavo Costa an experimental composer and musician who founded and runs Sonoscopia, an institution dedicated to timbral explorations; Pedro Tudela, one of the most consecrated sound artists in Portugal; Luis Fernandes, a timbre dedicated composer that founded and runs Semibreve Festival, one of the best electronic festivals in Europe; André Perrotta, an international sound artist; Paulo Furtado, also known as Legendary Tigerman, a consecrated international composer and musician that constantly designs its own sounds; Tó Trips, the founder of Dead Combo, an internationally well known

instrumental music group that focuses their message in the sound of the guitar; Vasco Mendonça a contemporary composer with consecrated works and international awards.

Although this is already a consistent group of people to whom we thank the immensely important and representative practical and academic based knowledge, we initially wanted to go further and have an even larger group, extending to at least 20 professionals, but as every generation comes with its own history, it is important to bear in mind that this was a year with additional communication complications due to an ongoing Covid-19 disease pandemic.

As previously implied, timbre is sometimes a very intangible thing to talk about. There is still very little universal lexicon or academic understanding upon which we can hang on to, to approach the universe of timbre and emotion in a precise manner. Therefore, we confronted the problem in a practical and sincere strategy; we listened to empirical knowledge from the people who have been doing it for a long time, and then, we extrapolated what would be the relevant data to our investigation.

As the Grounded Theory approach intends to investigate a phenomenon by the actualities of the real world, without preconceived ideas or hypothesis, (Glaser & Strauss, 1968) we conducted these interviews with an open-conversation character about the compositional practice and the process behind the conscious design of timbre that is often inherent to the work of our focus group. Furthermore, we opt for open-conversation rather than common targeted questions because, we were interested in understanding the very particular and specific philosophies and methodologies that were behind every artist process, case by case. Lastly, we were also keen on making sure that not one of our questions would influence in anyway the kind of answers we were getting from the interviewees.

CHAPTER 4: THESIS STRUCTURE AND RESULTS

4.1 Thesis structure

From our interviews, a series of emotional perception interrelations were observed. From these, we extrapolate those that were more consistently described and highlighted by our focus group, thus compiling a coherent set of phenomena that we will explore hereinafter.

As the majority of the group pointed out the multi-layered valences of timbre as a basilar element for its study, we will start by briefly describing the way in which timbre gives us several clues of auditory information that complete a message, to which we will call the timbral message. For this we will firstly make a passage from the physical form of sound, to its perception by cognitive processes, (section 4.2.1 through 4.2.3).

Following the coherence of the structure of the interviews, we will proceed to explore the "Shifting Paradigms" phenomena (section 4.3), in which we describe the processes of personal associations that alter the way one relates to a sound in a particular and unique way. Within this section we will also include an analysis on the paradigms that affect human relation with timbre in a more general manner by exploring the effects of Referencing, Timbre and musical genre, Culture, Generation, Socioeconomic, and lastly Timbre and identity (section 4.3.1 through 4.3.6).

Since our focus group takes on various artistic areas, an approach to contextualize timbre in the various artistic forms was attempted. In this section we cover Timbre, art and context, as a look on the variables and dependencies that are inherent to the perception of timbre in areas such as music, theatre, dance and sound art (section 4.4 through 4.4.1).

A special fourth section, which we named Nature and imagination, was written to create a bridge between the associations we make from natural sounds and the consequent projected imagery on composed sounds that can include acoustic cues from these natural sounds.

Once the social study and the interrelation between human perception and timbre is concluded, we will move on to the set of acoustic events that were described by the interviewees as the most important in how the perception of emotion through timbre changes. In this fifth section we will cover acoustic concepts such as Gesture, Timbre

dynamics, Temporal exposure, Soundstage, Reverberation and will end with a slightly more in-depth exploration of the Spatialization phenomenon which, surprisingly ended up being the most mentioned phenomena in the interviews.

4.2 Results

4.2.1 Timbral message

The first, broadly agreed construct that tended to appear in all 12 conversations and that quickly defined the path of this investigation was the concept of multilayered timbre perception. What this means is that it is believed that there are multiple layers of perceptually necessary information, conveyed by the timbral message, that we have to make sense of. As stated in *Designing sound* (Farnell, 2010), the human experience of sound is a physical and psychological exercise. There is the part which treats sounds as a physical phenomenon, waves and materials, and there is the part that makes sense of it, extracting features and meaning.

By understanding how both these pillars affect our experience of sound, we will be able to encapsulate that knowledge into mastering the technique and allow for a great timbre design.

Inside this multilayer concept we can distinctly explore three separate layers that go into the process of decoding the timbral message; there is the physical phenomenon part of it, and there is the psychological side, which is further dividable into two different points of focus; The first, a mathematic and scientific approach, that widely proves and identifies the internal encodings of the cognitive process, and a second point of focus on a set of paradigms that are able to completely shift/bend the path of our perception.

For this reason it is important to preface the remaining discussion with the idea that present results in this investigation show that timbre was considered by all partakers as a concept too complex and dynamic to be defined or standardized in the basic emotions often used in these studies, such as joy, sadness, fear and anger. Instead, we prefer to treat timbre as a package of clues that is capable of evoke and modify very particular and complex states of these emotions, that will ultimately differ from individual to individual.

4.2.2 Physics

“Timbre has been conceived of as a multidimensional sensory attribute and as a carrier of perceptually useful information about the mechanics of the sound source.” (Giordano & McAdams, 2010) From a descriptive listening' point of view, which aims at the identification of acoustic sources or events, (Zhang & Kang, 2007) timbre is a particularity of sound that gives us very necessary pieces of information about the nature of the sound generating event. These come disguised in a tightly arranged package of information that once opened, unveils a big number of tiny little clues. These

will help us identify the source of the sound, and therefore, the materials involved, the size of the material, how the material was excited, the force, the velocity, the characteristics of the space, the size of the space, and so on, offering different packages of information depending on the nature of the sound generating event.

The process of unmasking all these overlapping cues is called segregation and it is responsible for taking all the overlapping frequencies and acoustic cues that arrive to our ear simultaneously and by dividing them. It takes every bit of information separately and tries to understand or infer its source. As an example, it is known that for the case of instrument identification, the attack portion of the sound is key (McAdams & Giordano, 2009); nevertheless, if the attack is somehow removed from the sound, it is still possible to find clues in the sustain portion of the sound, especially if that sound contains vibrato, given that it may help us extract information about the resonance structure of the instrument. (McAdams & Rodet, 1988).

4.2.3 The psychoacoustic stage

Although there is a very concrete and palpable side to these set of clues that concerns no more than the sonic result of a mechanical action into a material, there is still a gap to their meaning. The psychoacoustic stage is the part of the process that will fill that gap and make us able to identify the source of the sound by a series of known psychoacoustic internal processes.

We can simply think of this stage as the process that makes one able to identify the sound of, for example, a car passing by without even seeing it. Roughly putting it, the car motor has those above mentioned physical and mechanical characteristics, that cause its sound to manifest as explosive, percussive and rhythmic while muffled by the hood, which will automatically fall into the category labeled in your mind as the sound of a motor. Add to that some Doppler effect and the sound of the wheels rolling in the asphalt floor, which you will quickly reference as a moving vehicle and lastly conclude that that sound, was a car passing by.

As much as all the processes and causes involved in the identification of a moving vehicle were here simplified, the relationship we have with sound does not stop there. Imagine that this vehicle has a very peculiar random high pitch squeaky sound. This will not only distinguish it from all the others, but also, make you able to identify that this is the same exact high pitch squeaky sound of the model of your grandfather's car. This last link, can make you relate to the sound in a completely different way, can it not?

This last modulation of the emotional relation we have with sound was shown in our results as the third layer of significance that is able to fully change the path of perception. To this third layer we shall call, “The shifting paradigms”.

4.3 The shifting paradigms

With this term we refer to the internal and personal associations one tends to imprint on a given sound event. This is the third part of the process and it acts like a modulation wave on the physical and psychoacoustic clues carrying them into an abstract layer of meaning.

Composer Tó Trips, refers to this stage as “The beginning of an emotional moment. It would be the gateway entrance that gracefully opens for the house of emotion. The relationship is emotional and consequently physical; How does that specific sound resonate in your in your mind, and body? Those consequences help in the splendor of the emotion perception” (Trips, personal communication, 2020)

This links to the above reference of a “random, squeaky sound” in the motor that is similar to the one that you were used to ear in your grandfather’s car. If the paradigm is “good” i.e., if you love your grandfather and you miss him, maybe you will feel nostalgic when hearing this sound, but if the paradigm is associated with something bad, you may feel angry about this noise. Borrowing LaBelle’s words regarding soundscapes, “you can almost feel that an entire history and culture can be found within a single sound, from its source to its destination, sound is generative of a diverse range of experiences, as well as remaining specifically tied to a given context, as a deeper expressive and prolonged figure of culture.” (LaBelle, 2010)

What is not so simple about this is that we cannot possibly know every person’s internal paradigms and contexts to that degree and extent. Nonetheless, if we are trying to efficiently design the timbre of a sound to fit a certain emotional message that we want to express, we need to try and look at a bigger picture and be aware of these shifting paradigms so we can work with them.

Here is an example: Artist Pedro Tudela thinks of the design of timbre a little bit as he thinks about color, he seems to believe that designing or finding a timbre from scratch is like chroma, like searching for your color palette, “of course that in their own singular existence, colours do not express an emotional message, instead they are one of the many clues that can help you begin to identify it, just like the many little clues that compose timbre.” (Tudela, personal communication, 2020)

Film composer Pedro Marques cites Tchaikovsky as a good example of someone who really got its color palette just right. Throughout the famous “Nutcracker Suite”, we can hear the celesta and the glockenspiel as very important voices in the piece, initially because of the metal characteristic present in the idea that these are lead soldier characters, but also, although a bit unconsciously, Marques says, because he was arguably induced by what Christmas really represents; The bell like characteristics of the timbre of the glockenspiel and the celesta, closely relate to the religious traditions of Christmas time, but the sound is not as rough as a church bell though. Instead, it is more rounded which makes it feel more comfortable and warm, at the same time it is tiny and scintillant as the imagery of the stars in the night of Christmas and bright and light as the happiness of being in family. Composer Marques adds, “it’s no wonder this became the sound of Christmas, it was so spot on that no one in the next few years could come up with something that impersonated Christmas better than his sound.” Point being, that there are some social macro scale paradigms that can work in favor for an effective emotional link to the sound, provided that we are attentive to them.

This brings us to one of the cognitive processes believed to greatly effect the way we relate with the timbre of a sound;

4.3.1 Referencing

What is the sound of a “Star Wars” laser gun, or lightsaber swooping in the air? Can you hear it?

I am almost sure that you’ve heard it in your head as soon as I asked this question, but now think about this, how can you have heard the sound of something that does not even exist nor make any noise?

This is referencing making its job. Much like the Tchaikovsky sound set the timbre of Christmas for decades to come, the insanely famous “Star Wars” saga, also created and established what would become the reference for the sound of a laser gun and a lightsaber. (Gomes, personal communication, 2020) Throughout our entire living experience we will always be exposed to cliches like these that will create a series of expectations about the sounds we hear, and therefore will unconsciously link them to specific memories and situations that can evoke an emotion.

4.3.2 Timbre and musical genre

Professor and researcher André Perrotta explains that our listening does not start from zero, i.e., as soon as we hear something we are always looking to find for the closest reference to it, so we can easily make sense of the sound. (Perrotta, personal communication, 2020)

If we bother to take a quick glance at music genres, we can find a very present emotional and timbral link;

Different genres of music presume different emotional attitudes, as Marques exemplifies, “if you try to completely change the timbral character of a music genre, you will probably lose a lot of public, because you are changing the message of the genre and therefore the emotional attitude. (...) distorted and percussive guitars, still are and will for long be rock guitars (...) Nirvana had a very unique attitude that came from the anger and frustration that Kurt had of its childhood, (...) that manifested into those growls of distorted guitars and loud powerful drums (...) Grunge has an attitude of insurgency, and that makes noise (...) so they also needed loud cymbals that were able to fill the spectrum” (Marques, personal communication, 2020)

Perrotta takes funk music as an other example, it has a very identifiable set of timbres that compose the musical genre, and one example of the most particular and present sound in it, is the bouncy, clean and energetic electric bass, which comes from the attitude associated with the already culturally bass heavy African-American communities music, that intended to create an happy and danceable music, and thus the use of this energetic and bouncy low frequency lines.

It has also been pointed out that time and tempo are an inherent characteristic of each individual musical genre and that these, effectively help define the timbres that go into every musical genre, “There is no time for long, polite reverbs in grunge or punk music, and it is also difficult to fit long sounding drums into house music, they don't have time to evolve naturally” (Marques, personal communication, 2020). The way a sound evolves, conditions it to its own time, therefore it is very hard to get a long sustaining sound with a polite release into emotional attitudes like grunge, the insurgency attitude makes time unavailable, the urgency needs to be felt in the sound. (Marques, personal communication, 2020)

4.3.3 Culture

In terms of referencing by cultural characteristics the most flagrant is the religious case. As we explored in chapter 1, in the Byzantine era, architectural modifications were made to have a direct effect on sound. The intent was to create an emotional experience that should translate into a divine and mystical space with characteristics that would ultimately modulate the sound inside the church into very mysterious, kind of unnatural heavenly soundscapes. This design has a very direct link to the imagery associated with the religious idea of something ascending and coming through the heavens. Therefore a airy and gigantic sounding instrument like the church organ would make for a suitable timbral “color palette” for a religious instrument inside a church, that not only has a very powerful expelling of air through those big resonating pipes, as it also has a frequency spectrum that is capable of properly fill and spread through the entire space, exciting it to an overwhelming sound experience. (Carvalho, personal communication, 2020)

The question remains, what came first? Referencing is a never ending feedback loop that self induces its own references, sometimes because we are “spot on” like Tchaikovsky, other times because of repetition and dissemination like the “Star Wars” lightsaber or the religious case.

Even so, composer Marques argues that not only we have references that establish from repetition, or culture, but also by generational and socioeconomic nuances that come to greatly impact the timbres in use.

4.3.4 Generation

When it comes to the generational aspect, composer José Alberto Gomes, points out that one of the greatest changes comes from the range of the spectrum accepted by the public, that has greatly been altered over the years. The composer even brings to the table an ongoing topic that is being studied and it reflects the difference between the sound of period instruments versus contemporary instruments. As Gomes explains, the contemporary piano sounds a lot different from the pianos Beethoven wrote for in its time. Today’s pianos have a much wider spectrum, they present deeper bass in their sonic character, which is one of the main defining characteristics of the sound of the generation we are currently living in. So the question arises, are we really playing Beethoven’s music as he intended, if the sound has changed that much? (Gomes, personal communication, 2020)

Not only have we been expecting a wider filling of the frequency spectrum as a result of the sonic habits induced by the industrial revolution and the ever crescent noise in the

cities, but also because our sound systems and technologies opened up for new possibilities and enabled, for example, a new physical experience that comes from this low frequencies that increasingly have been growing as part of these last generation's sound.

Composer Luis Fernandes, as the artistic director of the electronic music festival "Semibreve", made a reference to "Theatro Circo"'s PA system. It is a very powerful, low frequency heavy sound system, and it has to be in order to play what we are now expecting from electronic music. As Gomes explained, we are now expecting a very wide filling of the spectrum and some of these low frequencies are so low that begin to act as a physical sensation through the body.

4.3.5 Socioeconomic

On the other hand there is the socioeconomic factor that Marques brings to evidence as the so called "instruments and music democratization". This term is used to describe the evolution that has been happening in the industry of music and instruments, and it is very self explanatory.

Without further venturing into the intricacies of the industry, it is enough to say that instruments and music were also dragged by globalization. These have been widely spreading throughout our societies and have been made accessible for a lot more people over the world and over the years. (Marques, personal communication, 2020) This is not necessarily bad nor good, it is just one other cause that comes to change the way we relate with sound and timbre. Making music for movies used to be a very elite based job, only a very few were capable of doing it, not only because, money wise, it was hard to have access to an orchestra or a recording studio, but also because it was seen as a gift that only a few had. (Marques, personal communication, 2020) Then digital tools for composing started to appear, and in the beginning it too was very expensive and not for everyone, which made for the soundtracks to have very particular sounds that became easily recognizable, because only a few people could use them, but then, the industry started to open up the digital possibilities to a wider public, things started to be, little by little, easier to have, which eventually made people live in a "sonic dream." (Marques, personal communication, 2020)

Marques, draws from the popular saying that "Distraction is always the enemy of creativity", to explain how the ever crescent possibilities for making music have been throwing us off the track, i.e., now there is so many digital and electronic offer of instruments and effects spread all over the world, that it is hard to focus and not be utterly contaminated. We start to explore everything and not mastering anything, not only that, but also remains the idea that what once could easily and concretely define the

sound of an era, or culture is now a never stopping mixture and mutation of sonic characters that only belong in a liquid world¹). This becomes a very close evidence for the “liquid modernity” envisioned by Zygmunt Baumann (2013), where it is mentioned exactly this eminent accelerated, and extremely volatile society.

If on the one hand we have cliches that are established due to repetition and fear of commercial failure on the part of industries, like in the cinema, on the other hand, we have a music industry so fast and spread all over the world, that the sonic character ends up being contaminated and always in constant changing, leaving little time and space for a sonic concretization of a culture or an era, thus contributing to the phenomena of acculturation. Marques, pulls the album “*Kid A*” by Radiohead (2000) to show as an example of what a difference it makes to compromise and master the instrument, he says “This is an album made in the end of the 90s and it still is an exemplary piece of music that has a very eminent concern with texture and timbre and it is so well crafted that could easily have been done in the present day. This ages so well because nothing commercial has evolved so that is craftier than this. They had only a few new electronic toys, like the Kaoss Pad, to play with and they compromised with them and played it until it did what they wanted it to do”. Thus evidencing the importance of compromising with your own system and having time to master it, as composer and musician Gustavo Costa (2020) explains, “It’s only by knowing and mastering your instrument, whether it is digital, electronic or physical, that you can express fluently”.

Interestingly enough, as mentioned above, our results suggest that timbre tends to hold its emotional value and character when it comes to attitude, which ultimately helps define the genre.

4.3.6 Timbre and identity

Ten out of twelve professionals interviewed considered timbre to be a character-defining tool. As was suggested in this study, timbre is a visceral and natural sensation, therefore, for layman's purposes, it does not require teaching since it is intrinsic, unlike the harmonic relationship which, although also very visceral in its consonance and dissonance components, is still considered to be a much more complex and rational construct than timbre. (Fernandes, personal communication, 2020)

The knowledge of timbre is a self-taught musical language that each and every person will acquire over its life. (Fernandes, personal communication, 2020) As such, it is extremely easy to relate with timbre, it is very immediate, personal and emotional. The mere ludic exploration of an electronic instrument, for example, ends up being a task as

¹adaptation of the term liquid modernity coined by the sociologist Zygmunt Bauman

simple as deciding what sounds good and what does not, and everyone is naturally able of doing so, it is innate. (Fernandes, personal communication, 2020)

For composer Luis Fernandes, 90% of his work is constricted to timbre decisions, he explains that timbre is associated with our own perception of what kind of music we like to do, as such, it is a very important tool to find and define your own aesthetics.

Recalling the “Shifting paradigms” and the “References” sections of this investigation, it is safe to assume that over the years, we all develop personal attachments to individual sets of timbres, consequently leading us towards preferences and deprecations that ultimately define our timbral identity. Therefore, it is only natural that composers, albeit often unconsciously, will consolidate a set of particular timbral characteristics as their “go to sounds”, “as if it were a color palette”, which often ends up defining the aesthetics of their work. (Gomes, personal communication, 2020)

“I try to have my own, personalized, sonic identity (...) it’s obvious that we could generalize what would be the sound of, for example, sadness, but there still is a lot of grey area in there and people will feel, in the light of their own lives experience, a sadness that is different from mine” (Fernandes, personal communication, 2020)

The same phenomenon happens in the far end of the process, the audience. This might create an association effect very similar to the musical genre, where it was suggested that timbres closely relate to the attitude, or emotional message of the genre.

Interestingly enough Zang and Kang, (2007) have made a statistically unassailable soundscapes study in which it was mapped the sounds that people found more pleasing in their environment and the ones that they did not. Results showed that more than 75% of the interviewees liked the birdsong and water sound best, and the most unpleasant sounds were industrial and construction sounds. Although there is a general agreement among the interviewees, one has to ask, what birdsong? What water? What industrial sounds? For how long? Each and every sound has infinite versions of itself, a waterfall can be very pleasant, but a water drain can be very annoying, or vice-versa, it is dependable on how you identify with that specific sound. (Carvalho, personal communication, 2020)

4.4 Timbre, art and context

From the results of the present interviews, the continuous evolution of the emotional codes associated with timbre becomes even more evident, that is, our emotional relationship with timbre is dynamic and incremental, and one of the valves that keeps moving this engine is art.

All of the artists interviewed in this investigation presented a pulsating concern with how music and sound should always have something new to say, as Gomes says “It is the challenge of art in general, I cannot arrive with something completely new that you have no ways to decode, nor something dated that has been already completely decoded, because it is not challenging and we (public and artists) want to be, somehow, challenged.” Timbre becomes a very important tool in this search for freshness and exclusivity in art.

Artists and professionals in these interviews seem to find timbre a very inspirational tool, Marques seems to believe that it is inherent to a composer to instinctively compose for a new sound that he has just heard and liked, “as if that sound had told him something special” and even advises emphatically, not to let that feeling go cold before doing something with it, “because very sincere and inspiring things come from very inspiring sounds.” (Marques, personal communication, 2020) The ludic search for a sound, sometimes tweaking and collecting guitar pedals or electronic machines like synthesizers are very important timbral exercises and inspiring escapes that bring along other forms of discourses. (Lima, personal communication, 2020; Martins, personal communication, 2020).

Furthermore, composer Gomes refers that timbre has a very particular plastic nature, in the sense that it is completely able to be modified, composed and designed, thus possessing the possibility to widen our sonic lexicon and raising our art to more complex levels of expression. As such, it was suggested that timbre can be seen as being able of having its own artistic expression, separated from other musical cues such as pitch or intensity, thus behaving as an artistic object by itself, “the idea that even a short single sound on its own can tell you everything” (Gomes, personal communication, 2020), which for Gomes was the thought that ultimately created bridge between the world of music and the world of sound art.

As mentioned before, there has been a general consensus amongst the partakers in this investigation that there are some existing paradigms, and that these, effectively shape the way we emotionally relate with timbre, nevertheless, these “truths” or standards, should not be carved in stone. As opposed to the above mentioned effects of the liquid modernity, there has been a constant artistic struggle to maintain the relation between sound and audience, healthy and interesting by actively counterbalancing the standards and the volatility of this era.

Composers Rui Lima and Sérgio Martins feel that the way the audience experiences sound has gradually been evolving in the last 10 years, and that this is also freeing sound and music from its traditional functions. They make an allusion to what making

music for theatre used to be, and describe it as very cinematic, i.e., music used to have a very dramaturgic role, almost always underlining the emotion that the audience was supposed to be feeling, in the same manner sound design also had a very close relation to what we might be seeing on stage or the concrete sounds related to that scene. However, the consensus now, is that there is a general effort to never format sound into eternally rigid concepts and standards, as Lima and Martins say, “It is very annoying to be saying the same thing over and over again, like it was a recipe (...) we have already made over 100 soundtracks, what are we going to say next? Who would want to ear us again?” For this reason, it is not surprising that our results have shown that the artistic context in which a sound is presented, has a very heavy impact on how we receive the emotional stimulations of timbre. As Lima and Martins suggest, “we cannot talk about the same “timbre idea” in theatre and dance, hell, we cannot talk “timbre” from play to play, it all depends on how you are saying things.” That is, our relationship with timbre varies when the artistic context changes as it is dependent on the contextual variable of areas such as theatre, cinema or dance.

As our perception of the emotional expression of timbre has been evolving in an incremental manner, it becomes apparent in our results that artists make use of areas like theatre and dance to manage timbre in less obvious and usual ways. Evidences suggest that regular attending public tends to develop a tolerance to less usual functions of the sound, Lima and Martins notice that although some complex concepts like “musique concrete” are less obvious to the general public, there has been a gradual acceptance to the use of “less usual” timbres and sounds without definite pitch to express some sort of emotional message. “We feel that now we have a little bit more freedom to use music or sound in theatre not as an underlining part of dramaturgy, but as a free artistic object by itself (...) which becomes the exact opposite of, for example, the cinema and advertising industry, where there is an enormous pressure to keep perpetuating the same traditional functions of tonal music” (Lima, personal communication, 2020; Martins, personal communication, 2020)

All this suggests that we might have a level of understanding of timbre so visceral and immediate that we do not need the logical crutch of a line of dramaturgy or tonal cliches to relate to it emotionally. Corroborate with this idea, the studies that demonstrate that the recognition of emotion is more immediate through timbral cues than with the other acoustic cues, which take longer to be processed. (Eerola et al., 2012). This was also evidenced by the discoveries that listeners can distinguish various emotions from very short musical excerpts. (e.g., Peretz et al., 1998; Bigand et al., 2005; Krumhansl, 2010). Even so, Tudela warns about the importance of paying attention to the codes and physical limitations that are held hostage of the context in which we are working for timbre.

4.4.1 Context dependent variables

“In different situations, the same sound can give you several different sensations. You hear a howl at night, if you are alone, you are probably afraid. If you're in a group, it can be funny. If you're with your girlfriend, maybe it's sexy. If you make a saxophone cry, it can be sad or comical, it depends on the context...” (Furtado, personal communication, 2020)

Interviewees have suggested that the exercise of composing for different contexts has very different necessities and obligations.

For an artist, working for a context devoid of a global dramaturgy, or not dependent on a logical trajectory of a story, such as simply making music, means that there is a need to look for a self-motivation, that is, this sonic object becomes contained in its own individual and very particular system context, which contains its own abstract meaning. It is self-reflexive and with no necessary ties to global cliches or general interpretation codes. (Mendonça, personal communication, 2020)

Stravinsky used to consider that music by itself does not mean anything, “For I consider that music is, by its very nature, essentially powerless to express anything at all, whether a feeling, an attitude of mind, a psychological mood, a phenomenon of nature, etc. (...) If, as is nearly always the case, music appears to express something, this is only an illusion and not a reality. It is simply an additional attribute which, by tacit and inveterate agreement, we have lent it, thrust upon it, as a label, a convention – in short, an aspect which, unconsciously or by force of habit, we have come to confuse with its essential being.”
(Stravinsky, 1958 p. 53-54)

Meaning that music by itself, with no contextual constraints creates an inbreeding situation where it only relates with itself and its own meaning. (Mendonça, personal communication, 2020) However, if the composition exercise is applied under another existing context, like a movie, or a theatre piece, it automatically becomes an hostage of the existing contextual guidelines and conventions that we thrust upon it, i.e., in that specific context, there are a set of specific codes and cliches that our perception of sound and music may not be able to discard, in order to take meaning from them. There is a necessity to coherently illustrate the story that is happening in the movie and to accurately fill and manage the existing expectations associated with that specific context.

For a concrete and practical example of this, an allusion to the visual references in the theatre and cinema was made. This is related to the obvious physical limitations of, for

example, the materials that are staged in front of us and the consequent rapid referencing we tend to do, to the known acoustic properties of these materials.

Tudela presents the case of “Mercador de Veneza” a theatre play for which he was the set designer. In this play, it was important for the story to have visual metallic elements in stage, which the actors should interact with, but these were props and for safety reasons were made in plastic. This situation quickly became a visual reference problem, i.e., as an audience member, once you see the staged metal elements, you can no longer conceive that these elements would sound like plastic when touched, that timbre is now out of context and can lead you through rational and emotional conclusions that do not serve the dramaturgy of the play, if unintended. As such, timbre has now no other chance but to be latched to the metal like acoustic properties of the visual reference.

Also in dance, music no longer necessarily needs to serve the traditional functions. Yet, instrumentation (timbre) is still far from unlatching from the emotional intentions of the movement, or the dramaturgy.

Although, music can be seen as having many other functions in dance, results suggest that timbre can be a provocative stimuli, that highly influences and helps design the emotional intention of the movements, thus showing a strong connection with the existing evidences that suggests that the timbre is related to the physical and emotional state of our body. Fortunately we were able to take the “Brother” contemporary dance show by Marco da Silva Ferreira as a case study, in which I was able to have a very close observation of these effects as the live act performer of the music composed by Rui Lima and Sergio Martins.

The music was designed to maintain and sustain a dramaturgic idea, nevertheless, for the most part, music did not act as something that served the function of a measure of time or tempo, instead, the music was designed to work with “call and response” functions, i.e., the timbre of each sound that was launched on cue during the show, functioned as an emotional state motivator for the dancers, which they in turn responded with new changes on their movement, induced by their emotional relation to that timbre. 6 reruns of this show, with an average of 200 people as public, were observed and it became apparent in our results that dancers and public add a highly sensitive response, not only to the different timbres that were triggered during the show, but also that the most effective was a low synthesized, brassy sound that was designed to be scary. By briefly exploring the acoustic properties of this sound, that was equalized in intensity, we attribute its efficiency firstly to the very quick attack, followed by the large filling of the spectrum that consequently increased the loudness sensation, and lastly, a specially robust filling of the low frequencies of the audible spectrum.

Nevertheless, as we propose in this investigation, we should also consider the above mentioned perception related variables, and the additional acoustic and psychoacoustic phenomenons that we will further mention to explain the efficiency of this timbre.

In that regard, and as evidenced in our interviews, we now come to bring a set of acoustic and psychoacoustic phenomenons that were found to be of greater importance to an effective emotional timbre design by the partakers. As mentioned at the beginning of this thesis, we propose that there are a set of little clues hidden in every sound that, when working together like clockwork, will hint at a specific emotional correlation.

In no specific order of importance, we will start by analyzing the intrinsic relation between the natural sounds, the ones caused by natural and quotidian events, and the imagination, which is referent to our internal codings and imagery projections that we tend to project upon given sounding event.

4.5 Nature and imagination

Philosopher Ludwig Wittgenstein (1922), once asked “How do human beings manage to communicate ideas to one another?”

This question triggered a number of very interesting concepts and theories about the matter, and Wittgenstein’s answer, which became rather revolutionary, is that language works by triggering, within us, pictures of how things are in the world. In Wittgenstein his view, language enabled us to make sketched representations of facts and ideas. The problem is, different people tend to sketch different pictures of their own reality, unless something is true for both sender and receiver in a relatively similar way, the communication will fail. (Wittgenstein, 1922)

And this is where this interesting link between natural sounds and imagination is closely related to Wittgenstein’s theory. As mentioned before in the “Timbre and identity” section, our relation with specific sounds will vary with our own lives experiences, nevertheless, there are natural sounds that occur everyday and that are hardcoded into our brain as the obedient sound result of the natural laws of physics that deal with the materials, mechanics and energies. (Gomes, personal communication, 2020)

Results from our interviews suggest that there is a strong link between the sounds we know naturally from everyday life and the way we relate to timbre.

As mentioned before in the chapter about physics and “sound source identification”, our cognitive process is very capable of identifying the source of a sound, from the materials involved to the surrounding space, depending on the package of information that, that sound contains. Even so, our interviewees seem to think that natural sounding

events like running water, hitting rocks in each other, the wind, fire, etc., have a way of feeling very similar from person to person, making them a very important tool in this search to effectively communicate an emotional idea without leading to very different sketches in peoples minds.

Composer Gomes reminds us that context and mastery should always walk side by side, e.i., if there is a need to design a sound as close as possible to a real sound, say an helicopter, it is extremely important to know and think about every physical phenomenon involved in that sounding event. It is not enough to know that the sound of a helicopter is close to the white noise with some modulations happening and some filters, it is also imperative to think about the complex physics involved. Gomes recalls a sound design class with Andy Farnell where, to make the sound of a helicopter, Farnell went on to explore and describe every single physical process that latter implemented into the making of that sound, “it was only then that our hearing was fully convinced that that sound, completely designed from scratch, was a helicopter”. (Gomes, personal communication, 2020)

If we make a small effort and recall the example of the star wars lightsaber and laser pistols, which belong to a context and history far from our reality, we might now be able to understand a little better why these sounds worked so well and spread through the world without raising many questions.

These sounds, although completely imagined, are so convincing because they obey certain rules of physics that belong to nature and reality as we know it, or at least they deceive our brain into thinking such.

Much like the accurate sound design of a helicopter portrayed by Gomes and Farnell followed the actual physical phenomenons of the functioning of a real helicopter, in order to fully convince our brain, the lightsaber sound introduced natural and somewhat accurate physical phenomenons which translate in acoustic results that one might be able to hear in the seemingly real sweeping effect of the moving lightsaber, the electrical high tension characteristic of the sound that relates to the high energy associated to the production of such intense and energetic light, very similar to a big Tesla coil, the high pitch, quick attack, thunder-like strikes when lightsabers hit one another, thus making this sound more natural and therefore, more plausible to the general public.

In fact these nature-like characteristics of sound are so important to persuade our brain to “paint the right picture”, as Wittgenstein would say, that professor Perrotta (2020) is exploring the introduction of algorithms that mimic the laws of physics into procedural sound synthesis technology in is latest research. This research aims for the correction of

determined human motor problems by convincing the brain that the body is performing well in given a virtual reality environment.

This link between the physics present in nature as we know it and the way we relate with timbre does not stop at the above mentioned correlations, it goes far beyond, into much more subtle phenomena that deal with the relationship between frequencies themselves.

Composers Gomes, Lima, Martins, Mendonça and Trips, have all described a latent and constant relationship between musical timbre and nature. Gomes makes a reference to Tristan Murail and his music, which is known for its association with the spectral composition technique, where composition deals directly with timbral analysis and arrangements.

“At first glance, for my students, a Tristan Murail musical sheet seemed completely unreasonable and all those minute changes in frequencies and micro tones seemed very strange and distant from the music we are used to. However, once they started listening to this timbral work, it did not sound as unreasonable or as unnatural as it seemed, because these minute timbral changes come from, and exist in, physical processes of nature, which we are very used to.” (Gomes, personal communication, 2020)

As such it is no wonder that our results suggest that there is a latent desire for composers to include natural sounding acoustic properties into their own timbre design, composers Martins and Lima claim to use some natural sounds, like water or even ambients to help confirm the intended emotional effect, Tó Trips goes as far as saying that he only likes to work by moulding naturally existing sounds e.i., he seems to think of sound as a dormant condition of the world, already existing, that only needs his hand and mind to excite and mould them into musical form, “like the resonance of the wood of my guitar.” (Trips, personal communication, 2020)

Composer Vasco Mendonça ties all of these valences together and concludes by remembering the above mentioned Stravinsky notion that “music by itself means nothing”, to explain how he likes to use composite sound synthesis to add a concrete meaning to his compositions e.i., for composer Mendonça there are different orders of magnitude of sound. For this, he focuses on the ones that are abstract, such as the classical violin which is taught to be played by eliminating, as much as possible, the natural artifacts, such as the sound of the bow brushing against the strings, that otherwise would betray the source of the pristine sound of the violin, and there is the concrete “sounds of the world”, as Mendonça likes to call them, that bring a concrete, real and natural meaning to the musical composition, when mixed together.

“Music is closed in its own world and I also like to claim our world into it, that is why I find it very interesting when we have easily recognizable clues, like concrete sounds that mix together with the abstract sounds of instruments.” (Mendonça, personal communication, 2020)

4.6 Gesture

Following in our set of acoustic and psychoacoustic phenomenons that most effectively define our relation with timbre, comes the element of gesture.

“A big part of this timbre work is done by the interpreter, by the gesture. It is the physical expression of the emotional idea (...) the composer does one part of the work, but the other part is to have something or someone who captures and interprets the idea and completes the emotional message. (...) as electroacoustic composers, we have to be aware and be able to dominate all of these elements.” (Gomes, personal communication, 2020)

As proposed by present results, gesture will be defined in our research as the evolution of the timbral characteristics of a sound caused by, or analogue to, the human interaction with it, whether it be by digital, analog or physical mediums.

As suggested by our results, gesture is a fundamental force in our emotional relation to sound. The big or minute timbral changes caused by gesture are proposed in this thesis, to behave as another one of those little clues that will help us understand the intention behind that sounding event.

“Before talking about music, our communication, as humans, has a lot of necessary information to decode the emotional message hidden in the movements we make (...) Expressiveness has a lot to do with the physical component, (...) has a lot to do with the physical shapes and movements that people use to communicate.” (Fernandes, personal communication, 2020)

To understand this further, first we have to take a step back to the theories that prove that our relation to music is directly related to the way we communicate orally. As mentioned in the “state of the art” chapter, it has been suggested that humans interact with music and sound, in many ways, very similarly to how we communicate orally. It has been suggested that some acoustic cues in our speech are perceived as clues to effectively understand the emotional state of a speaker. (Scherer and Oshinsky, 1977) Juslin (2004) even came so far as to say that what makes a musical performance of, for example, a violin so expressive, is the fact that it can sound a lot like the human voice, while surpassing its physical capabilities, therefore suggesting that the brain can

consider some instruments as super expressive voices, this way corroborating with our suggestion that human cognition can detect and interpret such timbral variations as physical representations of emotional states.

Associated to these acoustic cues, there is also the movement of the body, as is suggested by the Spencer's Law, which states that feeling is a stimulus to muscular action (Spencer, 1857), thus explaining that emotion can influence psychological processes that lead to muscular reaction as a response.

An example of this is the emotional relation that a musician has with its instrument, that is in most cases, very physical. (Marques, personal communication, 2020) The body motor action of pinching a guitar string softly or harder or even the velocity to which you turn a synthesizer knob, calmly or furiously are the physical translations of an emotional message, which in turn translates to acoustic changes in the sound. Those performances and ancient human-instruments interactions, formed acoustic and visual references that became coded in our brains until present times. (Fernandes, personal communication, 2020) As mentioned in the "Nature and imagination" chapter, these references are also visually coherent acoustic results of physical actions on materials and machines that are now very difficult to liberate from our set of references. (Fernandes, personal communication, 2020)

This suggests that our cognitive process associated to listening is able to identify these gestures in timbral changes, and treat them as acoustic cues that are caused by this physical and very organic expression of an emotional idea, thus using those acoustic hints to decode the emotional intention behind the sound.

To further understand this phenomenon, composer Marques acknowledges that in a physical or analogue instrument, like a guitar or an analogue synthesizer, there is a very strong compromise to what the physical limitations are, there are no presets that you can save and recall, to make a determined sound one has to physically feel the instrument and make physical adjustments to the body and motor action to get a determined performance and sonic result, thus very often achieving very organic and life-like results, (Trips, personal communication, 2020) which presents very differently from the relationship one has with a computer, or a digital instrument. Although there is also a direct interaction between human and machine and there are ways to reach similar organic results, (Gomes, personal communication, 2020) in a digital instrument there is no direct correlation between one's physical action and the acoustic result, instead there is a virtual layer of algorithms that digitally simulate the intended results, thus making for no physical compromise and no visually physical action for a corresponding acoustic reaction. (Perrotta, personal communication, 2020)

For composers Costa and Fernandes this is the big gap in the relation that this generation's audience has with a digital performance, i.e., for the example of laptop music performances, or otherwise completely digital performances. There is a particular difficulty in accepting their place in the entertainment context, and part of that, might be because of this non-existing physical interaction with sound (Costa, personal communication, 2020) and the fact that sonically, a digital instrument can behave very differently from a physical instrument, for instance, there is the very unnatural particularity that in a digital instrument one can completely dissociate timbre from amplitude and even pitch to design a novel sound, (Perrotta, personal communication, 2020) making it less natural and therefore, harder to find close references and empathize, (Gomes, personal communication, 2020; Fernandes, personal communication, 2020) when otherwise, in a physical instrument, there is a natural behaviour, obeying the laws of physics.

Nevertheless, Fernandes thinks that this social construct only exists because we spent decades looking at musical performances in the same way, and believes that it might come a day when we can feel and understand a digital performance as well as any other.

As mentioned above, for decades, we have been accustomed with instruments that react to our physical interaction, “We like to see a piano virtuoso being physically challenged and sweating at his seat to obtain such sonic result (...) much like a guitarist or a drummer” (Fernandes, personal communication, 2020), therefore, we like the exercise to actively decode how the sound is being produced and manipulated. For composer Costa, in order to maintain a music performance interesting and emotional, one ought to include such clues that the public is able to decode and understand how the sound is being produced.

As a concrete example of this, Costa likes to talk about Sonoscopia's work and their recurrent solution to this problem. Their music is quite often based on the exploration of novel sounds and timbres found digitally, electronically or physically, nevertheless, to record and perform their music in an interesting format, they try to emulate some of those novel sounds, physically, into instruments or materials like metal, wood, stones, etc.

Costa explains that they tend to do so, because of two main reasons. The first is that digital or analog synthesized timbres tend to be very simple in their frequency relations, and therefore very unnatural, when, sounds from the “real world” have a tendency to have a frequency spectrum that is much more complex. (Costa, personal communication, 2020; Gomes, personal communication, 2020; Perrotta, personal communication, 2020; Marques, personal communication, 2020; Mendonça, personal communication, 2020) The second reason is that physically working onto these

instruments and materials, will give a much more natural translation of the gesture of the interpreter and therefore better references to help the public decode not only the source of the sound, but also how its being played, worked and manipulated, which in turn will carry an emotional intention. (Costa, personal communication, 2020)

As a concluding remark, it became very clear in our interviews the notion that the timbre of a given instrument or a sound cannot be thought of as having one intrinsic emotional value, e.i., the timbre of, for example, a violin should not be labeled as happy nor sad timbre, instead, we propose that we look at timbres as having potential for determined emotional expressions, once the gesture is capable of inducing such complex variations in the evolution of a timbre that it completely alters the emotional intention of a given sound.

Composer Mendonça refers to the timbre evolution as his main tool to design the emotional curves of his pieces, as he explains, “very often I find me thinking about the abstract component of timbre (...) I know I want a *ponticello*(2) passage at a determined time, without even knowing what notes to put in yet (...) timbre is the identity of the piece.” (Mendonça, personal communication, 2020)

As an example, the composer makes reference to the sound of the Portuguese guitar, that in Portuguese culture has a very strong connotation to Fado, a musical genre known for its very dark, heavy and sad emotional state, (Mendonça, personal communication, 2020) nevertheless, the composer thinks that the Portuguese guitar can have its own character outside the Fado culture, and the way to claim it, is to change the gesture to which it is used to be played. The composer explored the instrument for his new album, and in this case, the strings were not pinched, instead they were struck with drumsticks, thus vindicating its timbral potential to other states of emotion. To reinforce this notion, Mendonça mentions the Balkan violins that are played with such different intentions and cultural gestures that they inherit a completely different emotional potential than what we are used to in European violins.

In fact, this gesture exploration is also very evident in Lachenmann work and Mendonça makes reference to the composer’s piece “Pression” (1969), in which at no moment, the cello is ever played in a traditional manner, thus creating a completely unique emotional universe to that piece and instrument. Lachenmann calls this exploration “*Musique concrete instrumental*”, and it is related to the instrumental reproduction of a concrete timbral idea that goes beyond the traditional pitched music, resembling Pierre Schaefer’s “*Musique concrete*”.

² With the bow kept near the bridge so as to bring out the higher harmonics and thereby produce a nasal tone —used as a direction in music for a stringed instrument

4.7 Dynamic relations and temporal exposure

4.7.1 Dynamic relations

As suggested by the interviewed group of artists and professionals, our sensitivity to timbre might be very similar to our sensitivity to silence, in the way that it is always relative to a previous or a subsequent sounding event, i.e., silence is felt as the contrast to the sounding event just before or after it, “creating silence is always a management of expectations” (Carvalho, personal communication, 2020) and so does timbre. (Lima, personal communication, 2020; Martins, personal communication, 2020)

Lachenmann and Salvatore Sciarrino are composers that claim a listening attitude that is at times very close to the threshold of hearing, thus, often creating a very big distance between the lowest amplitude sounds and the highest. This very dynamic relation of amplitude in their pieces evokes a very unique universe that guides our listening experience through very distant levels of expectancy and meaning. (Mendonça, personal communication, 2020)

“Il silenzio degli oracoli for wind quintet” (1989) is a very prominent case of this dynamic experience, and if we take a close listen to this piece, we might even come to notice that as the dynamics of the amplitude changes, also does the timbres and, therefore, our relation with them.

The interviewees believe that the emotional valence of a timbre can vary and it is dependent on the system in which it is contained, that is, as the silence is only as effective as the contrast to the sound just before or after it, so timbre seems to gain its relevance in contrast to the ones that came before or after it in that same music or system. (Lima, personal communication, 2020; Martins, personal communication, 2020; Mendonça, personal communication, 2020)

By analyzing the general dynamics in the piece “Il silenzio degli oracoli for wind quintet” (1989), one can quite easily understand that the composer, by managing the amplitude contrasts, can make a flute which is considered an otherwise very soft instrument, sound “nuclear” (Mendonça, personal communication, 2020) in key points of this particular piece, when compared to an antecedent sound; sound which in turn is both softer in amplitude and in its spectral character.

This phenomenon occurs because in managing expectations a very distant contrast has been created to the sounds that anticipated it, and although both sounds, by themselves, are considered soft sounds, when directly compared in this music, where the threshold has been set to a very low amplitude and very soft timbre from the beginning, the flute

gains a particular power, that is not usual outside this Sciarrino's threshold listening attitude. (Mendonça, personal communication, 2020)

This short analysis of the management of amplitude is to serve as an analogy to what we are trying to explain with timbre dynamics, which is no more than the perception of a direct comparison of one timbre state to another or itself.

This means that, if we consider a closed system like a single instrumented music in which the instrument is an acoustic guitar, this acoustic guitar has a potential to have various states of emotional valence, that can be induced/achieved, for example, with the gesture component that we explored above, i.e., this acoustic guitar can be played from a very mellow to an extremely harsh manner, thus implying a range of very different emotional states when compared to itself and its own timbral states.

Nevertheless, if we now add another instrument to the same music/system, such as an electric guitar with a growly distortion, automatically we will be comparing the two timbres with each other and deciding which one is telling us what. (Lima, personal communication, 2020; Martins, personal communication, 2020) Suddenly, the harshness one can feel from an acoustic guitar is nothing when compared to a growly distorted guitar, and this contrast is what is driving the emotional valence of each one of these instruments. As Lima and Martins explain, in their composing exercise, there is always a conscious worry about where the timbral threshold for that specific music/system begins and ends, "We always want to be able to reach a determined state or message, and for that, we need to anticipate and cautiously build our way into it." (Lima, personal communication, 2020; Martins, personal communication, 2020).

Nevertheless, the latter example comparing the harshness of an acoustic guitar to a distorted electric guitar should not be held as an universal truth, since, as we have been exploring until now, there are a vast set of acoustic and psychoacoustic effects that can completely alter the path of our emotional perception, and reverse the latter comparison.

This management of timbre contrast not only applies to the distance between different sounds in one system, but also to the evolution of a timbre in itself, what this means is that, the composers interviewed in this investigation, also showed a significant interest in the way in which a timbre progresses and evolves from its beginning to its end.

The notion that was established from our short experimentations was that, to better define an emotional intention with a sound in a system, that sound should complete a timbral gesture and at the end, find a way to fall in a state that contrasts with the next timbral change, a notion that was further observable in the above mentioned "Brother"

dance play, in which Rui Lima and Sergio Martins his music always had a way to progress in incremental timbral steps.

Beginning with a sound that would only occupy very little space in the full frequency spectrum, gave them a great margin to induce timbral evolutions to that sound by inserting effects like distortion without ever crossing to the next stage, when a bigger impact was needed. The interesting phenomenon of this timbral management is that when the moment finally came, where the music would need the most power, opposed to the beginning, we did not even needed to use any distortion, to upstage the antecedent sound or to make it feel bigger, all we did, was to manage the expectations by finally and rapidly fill the rest of the frequency spectrum that we were building and hanging on, thus creating a sense of another new level that surpassed the antecedent sonic event, this way leveraging the emotional valence of this sound.

Composer Luis Fernandes further states that he tends to work much by contrast, the composer points out that he finds very effective to work the difference between effect and non effect, the relation between sounds with very distant spectral identities and even to contrast the sensation of big space and no space, which we will further explore. (Fernandes, personal communication, 2020)

By exploring this contrast phenomenon, we also found that the management of timbral emotional valence was also very dependent on the time we are exposed to a certain timbre, for that end, we will explore the temporal exposure, as one other psychoacoustic effect that is also been considered by the partakers has an effect that has the capability of altering the way we emotionally relate to a given timbre.

4.7.2 Temporal exposure

“What do you think about Sunn O)))? (...) These guys seem to never have a consensual public, not even the same person can say the same thing about them today or tomorrow! (...) For me, Sunn O))) is as aggressive as that is, only at the beginning, if you listen to that for an hour, at some point it sounds like hypnotic drones and you don't even hear distorted guitars anymore, you only hear frequency modulations that are kind of relaxing...” (Lima, personal communication, 2020; Martins, personal communication, 2020)

From our results, comes the notion of temporal exposure and its interaction with our emotional relationship to timbre. Our results point to a very coherent conclusion that our relationship with a timbre is dependent on the degree of familiarity we inherit from our exposure to it. (Fernandes, personal communication, 2020)

Composer Luis Fernandes states that often when listening to music he experiences an effect which differs very much from sound to sound, the “degree of familiarity”, as the composer likes to call it, is the degree to which you feel that you know and relate to that specific sound, and in most cases it varies, depending on the time and how many times you have been listening to it.

As mentioned by Lima and Martins, the specific case of Sunn O))) is an example of how being exposed to a sound for a determined period of time can effectively change the way we perceive it. At a first glance, Sunn O)))’s sound is mainly composed by the clash of low frequencies of highly distorted basses and guitars, with long sustaining chords, which would be considered as very aggressive. However, from the beginning to the end, the amplitude and timbral threshold of Sunn O)))’s music is defined and sustained always at the same maximum level that can exist in that system and over the entire time, one is exposed to it, therefore, the above mentioned dynamic relation phenomenon kicks into place. When the temporal exposure and dynamic relation phenomena work in close collaboration, our perception about a specific timbre can take an unexpected path that could lead us, as it did in this case with Lima and Martins, to perceive this clash of aggressive timbres as a relaxing drone.

In the exact reverse case, Gomes argues that, for the case of the timbre of a clean piano, which in general terms would be considered a soothing or pleasant sound (Gomes, personal communication, 2020), when listened for too long, may also become aggressive. “It is all dependent on how we present the sounds and how we manage them.” (Gomes, personal communication, 2020)

Similarly to this phenomenon, is Leibniz’s take on the auditory unconscious, that essentially explores the way we perceive sounds that we are exposed too. Leibniz likes to use the recurrent example of the man that lives near a mill or a waterfall, in which a continuous exposure to that sound, ends up eliminating it. Although Leibniz theory seems to explore the possibility that such man will end up not hearing those sounds when exposed to them for long enough, even though they are ever present, it actually goes beyond, explaining that although the man loses to be actively aware of that individual sound, he unconsciously knows it is there, because that sound is a part of the whole that composes that ambient, but we, humans, tend to blur that sound into the ambient, this way leaving us with a confused understanding of the whole. (Cox, 2009)

“Each soul knows the infinite – knows all – but confusedly. It is like walking on the seashore and hearing the great noise of the sea: I hear the particular noises of each wave, of which the whole noise is composed, but without distinguishing them. But confused perceptions are the result of impressions that the whole universe makes upon us; it is the same for each monad (Leibniz, 1989 P. 211).

Thus corroborating our results, the proposal that the time we are exposed to a timbre is able to alter our perception of it, hiding, collapsing or confusing individual characteristics and parameters of said timbre, in a manner that it can change the degree of familiarity we have with that sound, this way confusing preconceived sonic references that one might have and making possible to understand the whole, as a novel timbre, an abstraction, completely unlatched from its original source and with new emotional potential.

4.8 Soundstage and Spatialization

4.8.1 Soundstage

Before crossing to the more complex effects of the sound spatialization on our emotional relation with timbre, it is worth briefly noting the soundstage has a part of the whole realm of psychoacoustic phenomena that our study contemplates. This notion essentially describes the difference in emotional intention of a sound that is more present than the other and it is also connected to the above mentions of timbre dynamics and temporal exposure.

Above we talked about how the management of timbre dynamics affects a sound's emotional valence, a notion that relates similarly to the management of the soundstage layers. Sound is a three-dimensional event, it travels through space, as such, soundstage and spatialization are important details of every sonic event, and these should not be overlooked, as it is an inherent characteristic of sound. (Fernandes, personal communication, 2020; Tudela, personal communication, 2020; Lima, personal communication, 2020; Martins, personal communication, 2020; Gomes, personal communication, 2020)

“Humans perceive sound in space, perceive their distance, the direction of the sound, the movement of the sound, and that is all part of the hearing experience...” (Costa, personal communication, 2020) As such, it is only natural that the big or minute timbral changes that are caused by the space in which the sound exists, could lead to unexpected perceptual variances.

“A distorted guitar, in spite of having that aggressive character, does it have the same level of aggressiveness when it is on a more distant plane? That is, on a soundstage that is much more distant. (...) Putting it in another distance effectively changes the way we relate to the sound and therefore this level of aggression can be modified and altered depending on the relationship of layers that exists in the system.” (Tudela, personal communication, 2020)

Tudela explores the effect of taking a sound, presumably aggressive, as a distorted guitar and executes the mental exercise of locating that sound on a more distant plane, to explain how the level of aggressiveness of that sound can change or even be neutralized when in comparison to a sound on a closer plane.

This abstraction of layers of emotional intentions brings us a new three dimensional perspective to our perception of emotional timbre, that is, not only we have been considering all of the paradigms and psychoacoustic phenomena that induce or alter our perception of an emotion, as now, we are exploring the possibility of a depth to each emotional intention, e.i., arrangements of timbres in space in a way that its relative position and distance to the listener, would change the amount of emotional arousal.

The contrast of having that sound closer or farther is evident, nevertheless, this effect is not all due to the expectable sound pressure level differences, as Lima and Martins explain, it is a group effort of every chaotic physical phenomenon that happens when a sound exists in a space, and that eventually changes the final timbre that arrives to our ear. The unpredictable reflections, the sums, even the evolution and envelopes of the sound starts to mutate, and therefore, the perceivable aggressiveness of that guitar starts to change. Nevertheless, the physical phenomena called into attention are still not enough to describe this effect, there is also the fraction of the process that is responsible for the psychological aspect, the expectations and preconceived references that ultimately help us tell what is normal, or natural, and what it is not.

“(…) grunge is loud, it needs power and it needs to be upfront, in your face (…) if the drums doesn’t sound loud, if the voice doesn’t sound in your face, it doesn’t sound like grunge at all, you take away the intention” (Marques, personal communication, 2020) It is expectable that Nirvana had a staging of loud and upfront drums, guitars and vocals, if their sound did not meet that expectation, the emotional intention of their sound would not fall into the attitude that grunge portrays.

To explain it, Marques uses the example of the orchestra, where the instruments are usually distributed into different planes/layers and distances, and although there are a number of different classical arrangements, these did not tend to change much over the years nor have a fundamental difference from one to another because, there is always a natural tendency to balance the sounds in a more pleasant way, and present them in an almost two dimensional wall of sound (Marques, personal communication, 2020; Costa, personal communication, 2020)

However if one slightly outbalances that neutral expectation in one direction or another, human interaction to the sound starts to evoke other perceptual meanings that

ultimately will mutate the relation we have with it, presumably making that sound feel happier or sad, or even angrier, depending on the orchestration and its balance.

Schafer (1977/1994) envisioned a categorization of sound events in a soundscape that could easily be transferred to this proposed notion of layered emotional intentions for its organization of sounds into layers and planes that respect not only our perception, but also their distribution in the real physical space.

Its categorization is divided into sound signals, which are individual sounds that intend to communicate a certain message, like our voice in a conversation, keynotes which are the fundamental sounds that form the background of the sound event and are usually continuous, like the sea in a beach, soundmarks, in analogy to landmarks which are unique characteristic sounds to a particular place, and the foreground sounds, referring to those that naturally tend to stand out. (Etmektsoglou, 2019) “It is interesting to note here that the proposed sound event categorization is not absolute and universal. Depending on the listening situations, listeners’ personal history and their cultural background, one listener might decide that a certain sound is a Soundmark, while another listener could classify the same sound as a Sound Signal or even just as a Sound Event.” (Etmektsoglou, 2019 p. 12) One might perceive all these events as a whole but as mentioned before, the listener will not be able to make sense of every single layer at the same time, as human hearing is naturally selective. (Etmektsoglou, 2019)

Each one of these listening planes, is in fact distanced in the real physical space and it is reasonable to assume that the layer they occupy in our perception is directly related to their relative position to the listener e.i., a foreground sound is expected to lose its valence as a highlighted sound if it is in the same plane as that of a background sound, it will eventually be blurred and mashed into the background. In a similar way, every sound in a musical composition tends to occupy its layer and therefore its own valence.

A similar spatial distribution into layers was analyzed by Maria Anna Harley (1998) in terms of perceptual principles that contribute to the segregation of musical elements, where spatial differences between sound sources augmented the aurally perceived segregation of musical elements. “Like differences in time, pitch, timbre and attack, differences in spatial location are yet another means to enhance this segregation. In other words, similar but not identical sounds belong to separate musical layers when they are also spatially separated. (...) Many modern composers, such as Bartók, Boulez, and Stockhausen, intuitively use this principle in their music.” (Blessner and Salter, 2009)

“John Williams had a very unique sound to his orchestrations, because he had the opportunity to study and repeat and experiment with his musicians in the army (...) for

years he had brass musicians all for himself, so he knows exactly how to layer them and how to position them to achieve the balance of intentions and the timbre he is looking for” (Marques, personal communication, 2020)

The latter extraction of soundscape’s layers of significance could traduce the verified relation between the level of emotional intention and the soundstaging phenomenon that we propose in this thesis.

Although we agree that sound as an artistic medium such as music cannot always hold the exact same standards of categorization as a soundscape, we ought to be open for the possibility that listener and composer consciously or unconsciously mimic much of the same layer relationship of the soundscapes, as it is the most natural hearing process. “(...) the soundscapes we live in may in many ways enrich a traditional music education program (...) contemporary music education could benefit from a critical yet inclusive approach to the soundscapes we live in as teaching material.” (Etmektsoglou, 2019 p. 8)

4.8.2 Reverberation

Our results also reflected a great importance not only to the layered position of a sound in a space, as explored above, but also in the acoustic character of the space in which the sound exists.

“Your voice in a cave is very different from your voice in an elevator. If an extraterrestrial captures your speech in another galaxy, he might think that you, in the elevator, would be a person with one intention but that of the cave, would be someone else and with another intention. The extraterrestrial would be wrong, because the discourse is the same. The reverberation effect makes the content of the information very different” (Trips, personal communication, 2020)

While exploring this effect, Marques jumps onto the piano to explain how the place where the sound sits, can completely change the emotional valence of that sound; Quickly enough the composer starts to play a music by Thomas Newman from the American Beauty movie, which he claims it was written for a moment of the film with the intention to not judge, that is, the music was composed in a way that it should feel neutral, “not saying bad, nor good” about the families of that neighborhood at the beginning of the movie. (Marques, personal communication, 2020) Nevertheless, when we experiment playing the same piano melody, but now with a pronounced reverb effect on top of it, it instantly starts to change its emotional valence, effectively “falling towards a place a lot more sad and kind of haunted”. (Marques, personal communication, 2020)

By further exploring a number of different reverbs on top of this melody, we ended up reaching specific reverberation settings and chains that would mutate that haunted felling into more ethereal and uplifting sensations. Several similar experimentations with other interviewees were made and reached very similar results, some reverberations on parallel channels, only adding to the dry sound and some other in series, directly on top of the sound of the instrument, this way affecting even more how the timbre itself evolves, thus helping to suggest that reverberation has a great effect on the timbre and how it is perceived by us.

Such technique of introducing a specific reverberation to the instrumentation at a determined moment, is often used in the film industry to project a sense of solitude and sorrow to the characters, because “it feels very natural, adding this reverberation effects to the sound is a way of mimicking real life.” (Marques, personal communication, 2020)

This suggests that reverberation in music helps to portray the notion that a character is in fact alone in an empty space, by providing sonic evidences and hints that aid the imagery of the situation (Marques, personal communication, 2020), once again corroborating with the above explored Wittgenstein’s theory, that suggests that an effective communication is only expected to be achieved if the speaker can imprint a somewhat accurate mental picture in the mind of the listener. To that end, also composer and musician Tó Trips emphasizes the extreme importance of reverberation pedals on his music and performances, once they help him to achieve the general timbre that better expresses “the characteristic sense of distance and escape.” (Trips, personal communication, 2020)

Recurrently going along with this technique is the use of a single instrument to once again sonically hint for the solitude of the situation, such is the case of the opening theme in the Godfather movie, where the starting single trumpet is to represent the loneliness of that character who faces the world on its own. (Marques, personal communication, 2020) Further adding a specifically designed reverberation to that single trumpet, in addition to emphasize its condition as a lonely instrument, might be a powerful tool to also emphasize or slightly mutate its timbre, once the reverberation chosen could potentially sum or subtract some of the harmonic partials present in the original sound, thus changing the overall timbre and its evolution, as we will explore later.

Above, in the “Timbre, art and context” section, we mentioned timbre as an inspirational tool, because it inspired us to ear things differently and experiment with new sounds, that ultimately would widen our sound lexicon and make us able to express in many varied and evermore complex ways, nevertheless, adding reverberation to this process might be a way to benignly limit our “sonic-emotional” explorations.

Benignly we say, because, as explored above, when composing, we need to commit to a certain path at some point, (Luis Fernandes, personal communication, 2020; Gomes, personal communication, 2020) and according to our results, choosing where you place your sound, in another words, what kind of reverberation to use, one is effectively framing the global emotional state of that sound.

As an analogy to Schafer soundscapes categorization layers, reverb would be to the keynote layer, where a constant, fundamental sound is defining the global character of the soundscape, thus framing it. Reverberation wise, the choice of the space in which to place the sound is framing its fundamental emotional intention.

“If the piano is in this room I compose in one way, if I put it in another room I will compose in another way, because the timbre has changed and the timbre decides which way I go.” (Marques, personal communication, 2020)

As Marques explains, defining the reverberation in which the sound is sitting, is by a small or bigger amount affecting how the sound behaves in time, as mentioned above, it starts to mutate the general ADSR envelope of the sound, eventually causing effects as dramatic as completely blurring its attack, prolonging its decay, extending its global length and even changing the relation of the frequency partials that compose the original sound, which is suggested to be one of the main reasons why the reverberation is considered in this study as a very effective framer of the emotional potential of a sound and a limiter to the path which the composer may take. It is believed that in order for a sound to be able to complete a chord, it needs to be harmonically compatible, that is, the harmonic partials that compose the sound should enable for a sympathetic sum of another pitched tone, in another words, if a sound does not have potential for a major chord, it is expected to be very hard, if not impossible to make it feel happy. (Marques, personal communication, 2020)

A right balance between the sound and the space in which we may sit it to frame a pre-determined emotional state, might be difficult to achieve, but if we bother to take a look at it in a soundscape perspective, some clues might be found.

Reverberation in a soundscape can also affect our emotional relation, and has mentioned before, some behaviors of our natural relation to the soundscape should be considered in order to fully explore other forms of contemporary sound arts. (Etmektsoglou, 2019)

In 1988, an experiment has shown that with a constant SPL, noise annoyance is greater with a longer reverberation time, (Kang, 1988), this way predicting the above

mentioned effects on the timbre that presumably contributed to a more confusing and blurred sound.

On the other hand, it was found that balancing the reverberation time between 1 and 2 seconds, can make street music more pleasing. (Zhang & Kang, 2007) This way suggesting that the reverberation time, although dependent on the context in which the sound is presented, might be one fundamental parameter to its effect on the emotional perception.

4.8.3 Spatialization

In addition to the effects of reverberation, consciously choosing the localization, direction and action of the sound in space has also been extensively mentioned among the interviewees, as such, sound spatialization is viewed as another qualitative dimension with which we can analyze and design our emotional relation with a sound.

As previously mentioned, from the general perspective of all of our interviewees, the listening experience is a multilayered task that deals with a vast set of significant sonic cues, which then our cortex converts into perceptual hints, (Blesser and Salter, 2009) each of those carrying a latent potential to shape our emotional experience of the world. To that end, and as explored above, choosing the acoustic space where we place the sound, not only ends up changing the final timbre that arrives to our ear, as it also has a way to frame its emotional valence. Nevertheless, the partakers in this investigation believe that the behavior of sound in space is much more complex than the obvious acoustic modulations that are imprinted by the space, as the sound, the space and the listener are not always stagnant in the real environment. (Costa, personal communication, 2020; Lima, personal communication, 2020; Martins, personal communication, 2020; Fernandes, personal communication, 2020)

What this means is that the world as we know it, has a compound of spatial variables far more dense and chaotic than the mere acoustic reflections of walls and surfaces, as the sound and the listener interact with the space in an intricate series of acoustic and psychoacoustic reactions that ultimately inherit an identifiable personality, an aural architecture. (Blesser and Salter, 2009)

“If we transported a symphony concert into a forest, it would not have the aural impact, intimacy and immediacy of a concert hall (...) in each contrasting space, even if the sound sources were to remain unchanged, the aural architecture would change” (Blesser and Salter, 2009 p. 2)

The notion of aural architecture, has been prolifically described by (Blesser and Salter, 2009) to exalt and explore this intricate sound-space-listener relation, in which the conscious design of the triplex interaction can directly influence our moods and associations and even stimulate basic sensations such as anxiety, tranquility, frustration, fear, boredom, etc, relying on the design and the cultural context. (Blesser and Salter, 2009)

“Auditory spatial awareness is more than just the ability to detect that space has changed sounds; it includes as well the emotional and behavioral experience of space” (Blesser and Salter, 2009 p. 11)

For composers Lima and Martins, spatialization has a direct effect on how we relate emotionally to a sound, designing a spatial function to any given sound, is a direct contribution to the artistic discourse, “it represents yet another layer to our sonic expression” (Fernandes, personal communication, 2020) therefore, it helps give shape to the content of the message. As such, based on the expertise of our primary sources our research denoted that the majority of our interviewees agree on the general hypothesis that the practical matter of sound spatialization is divided into these three main components;

The localization, which is concerned with the three dimensional spatial positioning of sound sources in reference to the listener, the directionality, which deals with the orientation of the sound source around an axis centered on itself and/or in reference to the listener and the last, spatial action, which refers to the movement of the sound, around its axis and/or around the space in reference to the listener.

Although each of this components cohabit in the same perceptual function, we will start by focusing on the localization componente and join the rest to complement further on. We recurred to the exploration of multiple years of practical experimentations with spatialization in professional works by our interviewees, which has led to the general and very cohesive agreement that consciously choosing the location of the sounds in the listening space, is an extremely powerful tool to the sonic communication and to the artistic expression of the composer or the designer.

It was discussed that the convencional bi-dimensional wall of sound often used in most simulated music or sonic experiences of our quotidian life is nothing but a practical and comfortable compromise, that many times is holding the fruitful evolution and experience of sound. (Costa, personal communication, 2020) The conventional use of just one front or a two dimensional wall of sound, such as stereo, like in a rock music concert, or a symphonic orchestra, or even when watching tv or listening to the radio, is always a compromise on costs, mixing efficiency, time, logistics and otherwise multiple resources that the real sonic environment does not spare. (Costa, personal communication, 2020) In fact for Maria Anna Harley (1998) spatial music is only interesting because it possibilities and justifies combinations of sonic elements that would otherwise be artistically weak without spatial distribution.

In the real environment, sound exists in a three dimensional space and sound sources are spread all over our surroundings making us aware and making us experiencing the involving space.

Not only is the environment always giving us three dimensional clues, as our head, ears and cognitive process are actually tuned to enhance this spatial awareness in multiple

cognitive processes such as the “Head Response Transfer Function” model. This is a process that our brain utilizes to transfer the information about the behavior of sound when it hits the physiognomy our head into perceptual clues for source identification, for instance, the pinna of each ear is made of acoustic labyrinths that amplifies the sounds in the direction we are looking and also filters designated frequencies so that minor timbral changes can be felt to distinguish front and back and further make sense of the three main components here stated, the localization, directionality and movement. (Farnell, 2010)

This process relies directly on diffraction and absorption effects, therefore frequency and overall timbral changes are crucial, (Farnell, 2010) in fact it is known that as a general rule “higher frequency sounds with sharp attacks are localized better than low ones with soft attacks. We localize sounds best at their start times, in the first few milliseconds of the attack transient. Sustained sounds are harder to locate.” (Farnell, 2010 p. 79)

Placing a sound in front, to the sides, in the back, under or above the listener has by itself its own powerful set of effects on the subject. In a given context, making sense of where the sound is coming, is not only an essential surviving skill, as it is one of our most important navigational tools (Blessner and Salter, 2009) the subtle timbral changes to the sound, such as frequency filtering and envelope mutations, are sufficient to cause cognitive relations about its position and assess the situation and therefore evoke emotions like fear and relief. (Lima, personal communication, 2020; Martins, personal communication, 2020)

“In a theatre play, it is not the same having a bass sound coming from the far back of the stage, or having it come out right on your face. Its not about presence or loudness, is about where it is in relation to you, how it relates to the space, its about storytelling, (...) you feel it differently and you take two very different meanings from it” (Lima, personal communication, 2020; Martins, personal communication, 2020)

An abstraction of this effect is the example of the two counterpointing scenarios; the first is of a crazy man who is wondering around and screaming in the hall of your building floor, coming and going past right outside your door. Counterpointing is a second scenario where the crazy man is placed outside your building, wandering and screaming in the open streets. Both in the first and second scenarios the listener cannot see the man, only listen and infer his position.

By recurring to Salomé Voegelin’s (2010) approach to the objective-subjective listening, which looks to sound not only as the sound object, but also as the unique experience that each one of us, in our own terms and inter-relation, imprints on it, we can infer that

in the first scenario, the localization cues of the sonic presence of the crazy man, announced not only an uncomfortably close presence in reference to the listener as it also presented an unwanted interaction to the listener's personal space, adding to that, the constant direction changes of the man coming and going feels unpredictable, contributing to invasion associations and leading the subjective listening to evoke moods of fear and anxiety.

By the same principle, the second scenario presented a sonic localization of the man that portrays a much more comfortable spatial relation to the listener, and a much safer interaction of the crazy man with the listener personal space once it is now out of its bounds, further releasing the tension to a sensation of relief.

By designing an aural architecture that concerns not only the position of the sound source in relation to the listener, but also the interaction of both with the space and context, much more complex and interesting meanings might come to take place, as the aural experience concerns both hearing, which deals with the detection of sound and listening which is the active interaction to the meaning, emotions, and symbolism contained within sound. (Blesser and Salter, 2009)

“Listeners react both to sound sources and to spatial acoustics because each is an aural stimulus with social, cultural and personal meaning.” (Blesser and Salter, 2009 p. 11)

In order to portray the direct and practical emotional effects of this interaction, Lima and Martins, shared part of their sound design process for “Casa & Jardim” (2012) theatre play at Centro Cultural de Belém. The intention of this design was, at a certain moment, to create an acoustic sensation that the CCB building was about to collapse, thus inducing a great sensation of fear to the audience.

To achieve this, Lima and Martins went on a process to which they called the “search for the sonic truth”, e.i., to compel the audience to feel fear, it was imperative that the acoustic result of their work was very credible, as such, the composers went on a "search for the real timbre of the CCB building”, which means, they tried to identify the real sonic personality of the space that the listener was going to be experiencing, what elements would shake if under pressure, and where were they located, what resonates, what are the fundamental frequencies of the space, etc. Once the aural architecture of the space was learned, the composers then enhanced and excited those exact sonic particularities of the space, respecting their location, directionality and overall behavior so that the listener would feel a truthful sonic interaction with that space and therefore, really believe that the CCB building was going to collapse.

Of course, the audience's visual realization of the space plays an instrumental role to this effect, as the cognitive process aligns the aural sensation to the visual cues. Visual and aural are parallel adjectives as their stimuli often reinforce each other, and being both aural and visual cues coherently aligned with each other, emotional associations are shared. (Barry Blesser, Linda-Ruth Salter)

"The visual vastness of a cathedral communicates through the eyes, while its developing reverberation communicates through the ears." (Blesser and Salter, 2009 p. 3)

Even so, convergent to Barry Blesser and Linda-Ruth Salter's (2009) conclusion, also our interviewees identified the parallels between aural and visual stimuli, yet, to explore this additional layer of sonic communication as an artistic tool, the effects of visual and aural incongruity were observed.

"Although we expect the visual and aural experience of a space to be mutually supportive, this is not always the case. (...) the visual and aural attributes proceed conflicting response." (Blesser and Salter, 2009 p. 3)

As a case study of the practical interactions of these perceptual components; context, sound source, spatialization, directionality, evolving space and listener, Lima and Martins share the details and results of their sound design for the theatre play "Memorabilia" (2011) to illustrate the phenomenon. For this play, the conventional routines were replaced, that is, the audience stayed on stage with the actors, instead of being in front of the stage. Speakers were scattered throughout the conventional audience seats in front of the stage to later on reproduce voices of lyrical singers, adding to that, a speaker for a minaret voice was placed on the top balcony of the theatre to spread and excite all of the space. The conventional audience seats and space in front of the stage were intentionally darkened in a complete blackout so the audience on stage could not see the speakers or have a visual reference of that big, empty space in front of them. Once the lyrical voices started to play from that void and unknown space, the audience could not have a visual reference of the sound source, nor its localization, directionality or the space that justified that sonic event.

The unpaired visual and aural stimuli, adding to the lack of understanding about the sound source, the displacement in its localization and direction, led to a conflicting cognitive response, furthermore the added cultural associations to the strange spatial lyrical singing without a body as its source, contributed to emotional associations of ethereal and mystical voices.

"It is confirmed, when you cannot see where the sound comes from, when you do not see the body behind the voice, when you can't understand the sonic event, immediately

you start creating fantasies. This misplacement of sound, this design that made space and sound seem unpaired or otherwise unknown, was what created all the emotion and divine sensation of the play.” (Lima, personal communication, 2020; Martins, personal communication, 2020)

As a remark, from this example we can further extrapolate that the choice of the lyrical voices and their relative localization in the theatre was an exercise of design of the direct timbre and spatialization interaction in order to evoke said ethereal sensation. As Salomé Voegelin (2010), LaBelle, B. (2010) and Stravinsky (1958) explore, the human relationship with a given sound is an experience of self-interactions and cultural symbols that we imprint on it, therefore it is expected that changing the timbre of this spatial sound sources, to say, vuvuzelas or a crowd cheer, would change the emotional associations, as those sounds, in our European culture, are much more coherent sonic symbol of an arena-like spatialization.

“Hearing, together with its active complement, listening, is a means by which we sense the events of life, aurally visualize spatial geometry, propagate cultural symbols, stimulate emotions, communicate aural information, experience the movement of time, build social relationships, and retain a memory of experiences.” (Blessner and Salter, 2009 p. 4)

Although the effects of directionality were not singularly approached, they present an intrinsic contribution to the listener’s relation to a spatial sound in the above examples, once as soon as you choose the localization of the sound, you automatically have to make a decision about the direction in which you want it to travel or to target, even so, a deeper perspective on its interaction with the listener and space might be found in psychoacoustic phenomena like “the cocktail party effect”. (Farnell, 2010)
As for our results, the directionality of sound can be seen in two joint or individual perspectives. In the first perspective, the directionality can be as objective as the desired acoustic effects of consciously pointing a sound source in a way that its acoustic interaction with the space creates, echoes, or other time and spectral effects that modulate the timbre of the original source, thus enhancing its interaction with the space and any dramaturgical or sensorial desire to complement the sonic message.

On the other hand, a deeper directionality-timbre interaction was suggested and it can also be seen as a subjective level of interaction to the listener, this way serving as a subjective tool to direct the listener’s attention. That is, a spatial sound that is intentionally oriented towards the listener as its target, can cause the listener to sense it as distinguished from the rest of the environment and focus on having a direct interaction to that specific sound, (almost as if someone is calling your throughs a

whistle at your direction), even so, directionality can also be achieved in the reverse sequence.

Such as the “cocktail party effect” suggests that a listener can intentionally choose their listening focus on a pin point sound in an otherwise confusing sonic environment, if that sound is of distinguished importance or pleasant to the listener, (Farnell, 2010), also by once again taking on Salomé Voegelin’s (2010) subjective sound explorations, we can extrapolate that by consciously choosing the timbre that is more significant to the listener, one can direct its focused attention towards a pin point on the space, even if that sound is not spatially oriented to target the listener, its attention is now directed to the sound, and it is even possible that from this, arises a real interactive experience as it is expected that the listener will physically interact by moving the face towards the sound, as facing the sound is an important action in accurate localization. (Farnell, 2010)

The spatial movement of sound could be viewed as a necessary consequence of all of this interaction between listener and space, as this relation comes to be bidirectional; Sound “calls”, a listener “responds”, vice-versa, a listener expects and a sound delivers, in whatever ways it may be, whether by evoking determined emotional associations, or even by physically following the sound if compelled as much, the cognitive process of experiencing sound makes us to take action, and in humans this happens at a very low level in the brain maybe because we are not able to block sound with “ear lids” (Farnell, 2010) like the visual sense can, which eventually makes us very susceptible and obliged to process every sonic event. (Lima, personal communication, 2020; Martins, personal communication, 2020)

“Hearing is the most hypnotic sense we have” (Marques, personal communication, 2020)

Therefore a movement between emitter and receiver is initiated, almost like a dance in which the movement of the sound serves as yet another cue for the whole of the sonic message, in which the interaction of the sound with the listener and the space shows new and evolving perspectives and rearranges the contextual meanings. (Costa, personal communication, 2020; Fernandes, personal communication, 2020)

Making this train of thought less abstract, we suggest to take once again the example of the crazy man screaming and wondering around in the hall of our building floor; its constant change of directionality and position in relation to our door, gives the listener the sonic information necessary to associate that sonic movement to a concerning sense of instability of this man, almost like if we applied a sinusoidal with random frequency

modulation to the position and directionality of the sound and as a result, it causes the listener to experience constantly unstable assessments of proximity and danger.

For sonic artist Tudela, this movement interaction is an instrumental capability of sound that shapes our emotional experience of timbre, as these are once again intrinsically connected. The consequent timbral modulations of moving the sound in reference to the listener or the space have the ability to completely change its acoustic personality and/or displace it from context, making for an instrumental force when designing sound (Tudela, personal communication, 2020; Costa, personal communication, 2020; Fernandes, personal communication, 2020).

Tudela uses his presential experience when attending to Alvin Lucier's "Empty Vessels" (1997) piece latent in a gallery to portray the fundamental interconnections of spatialization and timbre, by exploring the effects of a moving listener in relation to multiple stagnant sound sources consciously located through the space.

As a form of contextual guideline, "Empty Vessels" (1997) belongs to a series of Alvin Lucier studies of the resonance characteristics of small interior spaces. For this he has aligned eight glass vases on pedestals, microphones were then placed at the openings of the empty vases and each audio signal is then routed to eight speakers that are positioned on the exact opposite side of the space, each speaker facing its correspondent vase. Every speaker receiving its correspondent signal is carefully calibrated so that system is at its feedback limit, being that each speaker and feedback corresponds to the fundamental frequency of each corresponding vase.

"(...) This creates a controlled feedback field of resonant tones and their interferences in the gallery space. When entering the field, the visitor disrupts the delicate balance of the system, creating new feedbacks with unexpected frequencies. Even a small head movement is enough to hear a multifaceted, fluctuating spectrum (...)" (Lydgalleriet, n.d.)

Firstly oblivious to the practical concept of the piece, Tudela starts to create his own relation and experience when entering the space. The artist's first impact was the considerable difference in light intensity when entering the space, which consequently made it more difficult to understand what were the objects displayed in front of him, and also was noticeable a sound that was almost like an unstable dark environmental drone that was very hard to perceive where it was coming from.

The first impressions of the artist led him to feel that room as a bit ethereal because he could not see the source of the spatial sound, it also felt emotionally heavy, such was the character of the sound drone, yet, the prolonged permanence of the artist in that space started to make him able to little by little adapt his eyes to the brightness of the room and to perceive that those objects were in fact empty glass vases with microphones in

their mouths and that the moody dark drone was the resonant result of the sound source, space and listener interaction, as such, at this point the context changes drastically, as the visual reference transports that timbre to its real justified source, taking it away from the first ethereal associations. Ultimately the artist realized that his movement around the space caused both objective and subjective changes to his experience as his relative position to the localized sounds allowed him to continuously have different sensations, as his movement in space created changes in the timbral character of the drone, which consequently created constant subjective context rearrangements, as if the interactive experience of sound, space and listener compelled each other to “dance” or “converse”, exchanging meanings and emotional associations.

“The circulation in the space generated different interactions automatically and that effectively shapes or sculpts the sound and our relationship with it. (...) what matters is what kind of role we internally give to the sounds ” (Tudela, personal communication, 2020)

In fact composer Fernandes likes to take Morton Subotnick’s 2019 concert at Semibreve Festival, as a case study of the intuitive use of all of the mentioned interrelations in this thesis. As we both attended to this performance, it was impossible not to agree that it was an indisputable demonstration of the intuitive use of all these timbral interrelations here explored, from his exceptional ability to sculpt timbre, to the way he fluently works the timbre dynamics, the concerns with time exposure, the context and even the gesture which was very present in his spatial relationship with the listener, which in this case was reversed, since the listener was stagnant and the sound was moving within a quadriphonic speaker system.

An interesting aside was related by Fernandes; when Subotnick was asked about the sound monitor system that he wanted at stage, to which he responded; “None! (...) I need to listen how my sound responds to the whole building, so I can communicate what I want, as I want to the audience.” And as Fernandes recalls, he was actually able to listen from around 25 meter away that one of his surround speakers, was not behaving as the other one... Subotnick becomes the figure of the mature use of the whole realm of physical and psychoacoustic phenomena here explored that effectively shape our emotional relationship with timbre.

CHAPTER 5: CONCLUSION AND FUTURE WORK

5.1 Conclusion

The outlined aim of this research was to provide a qualitative overview of the various phenomena and interrelationships that shape our emotional relationship with timbre. We believe that by understanding this phenomenon and its contours, we can contribute to artistic and sonic expression.

After analyzing the pre-existing literature on the subject, we found that despite the obviously extensive and dense scientific interest, there is still a large gap between quantitative and qualitative knowledge, that is, in terms of practical knowledge about the phenomenon, and knowledge extraction from practitioners.

To bridge this gap between scientific and empirical knowledge, we used a methodology that allowed us to collaborate directly with artists and professionals of proven relevance in the field of sound, and specifically timbre, to gather hands-on knowledge. Although this collaboration was limited by misfortunes associated with the current pandemic of Covid-19 disease, we were able to bring together a group of 12 respected professionals and artists for the study.

From this focus group, we were able to unanimously conclude that in addition to the timbral message providing us with concrete information about the sonic event, there is also an emotional valence that is dynamic. In other words, the interviews revealed that our emotional relationship to timbre depends on internal and personal associations, demonstrating an innate tendency to like certain timbres that is directly related to our own personality and acquired knowledge over time.

Nevertheless, we were able to list a number of external paradigms of a social, cultural, generational and economic nature that shape our perception in a generalized way.

In the series of generalized paradigms, it has also been proposed that the emotional perception of timbre in music may depend on the musical genre, since the emotional attitudes associated with the musical genre imply certain acoustic cues, such as rhythm, which directly enforce the choice of timbres that may exist within that system, as well as its evolution. It has also been suggested that the behavior of our timbre perception, when associated with different artistic forms such as music, cinema, theater, dance, and even sound art, becomes dependent on variables inherent to the associated context. That is, in the case of artistic contexts that do not have codes such as a visual component, as in music, timbre gains a freedom that allows complex and abstract sounds to express themselves beyond the concrete component, such as the envisioned "super expressive voices" described by Juslin (2004). In the case of cinema or theater, on the other hand,

the visual component, among other dramaturgical codes, conditions certain sounds and their behavior to pre-existing internal associations.

The case of contemporary dance and sound art are particular, since their constant evolution and disruptive nature do not favor the creation of such consolidated clichés or codes, and therefore our interpretation of timbre in these cases acquires a more visceral value, i.e., it was suggested that our perception of timbre is as immediate as it is incremental, and therefore this relationship has evolved to a state that is so visceral and immediate that in certain contexts the support of other contextualization codes, such as dramaturgy or defined pitch, is no longer necessary for us to extract emotional meaning from it.

From the practical perspective, the results have also shown that there is a cognitive level to our relationship with timbre that concerns the mental associations we tend to impose on complex sound events based on innate and acquired knowledge in nature and daily life. That is, from innate and acquired knowledge of the sounds of natural events, we tend to imprint some of these associations on other complex or abstract sounds in an attempt to interpret them, which in turn gives rise to fantasized imagery with corresponding emotional valences.

This perspective allowed us to bridge the gap between what is physically felt and what is psychologically relevant, and paved the way for practical research into acoustic and psychoacoustic phenomena that shape the projection of emotional valences into timbre. Our results point to aspects such as sound gesture, timbral dynamics and temporal exposure, soundstage, reverberation, and spatialization as the group of aspects that most influence the perception of emotional valence in timbre.

According to our results, sound gesture, defined in this dissertation as the evolution of the timbral characteristics caused by or analogous to human interaction with the sound/instrument, can provide acoustic clues that are characteristic of an imprinted emotional intention. That is, the way a performer plays the violin may provide acoustic clues about the emotional intent imprinted on each musical note or moment, just as a particular gesture on a synthesizer or digital instrument may be interpreted as an expression clue. For this reason, future research is strongly encouraged to create a database of sound gestures that can be better recognized by our hearing, and the resulting emotional correspondences.

Our results have shown that the exercise of dynamic management timbre becomes essential for the emotional valence we want to imprint on a given sound, i.e., by analogy with silence, which requires the context of the preceding or following sound event to become evident (Carvalho, personal communication, 2020), it is proposed that timbre

also has its relevance dependent on its relation to the sound event immediately preceding or following it. This makes possible the notion that any instrument can have any emotional value as long as the listener's expectation is worked up to that point, as in the practical cases of composers (Lachenmann and Salvatore Sciarrino). Moreover, some demonstrations and experiences showed that timbre expectation management can interact with the phenomenon of temporal exposure within a closed system, such as music.

Temporal exposure was highlighted in our results as one of the psychoacoustic forces that can fleetingly shape our emotional relationship with timbre. For example, prolonged temporal exposure to a timbre that is otherwise perceived as smooth and pleasant can cause it to become completely excruciating. (Gomes, personal communication, 2020)

As in the practical case of Martins (2020), who after prolonged listening to Sunn O))) began to lose the notion of aggressiveness that the guitars brought with them and instead gained a relaxing notion of sound drones, confirming the phenomenon that describes the relationship between temporal exposure and selective listening. (Leibniz, 1989)

In keeping with the perspective of exploring the emotional value of timbre, an internal relationship in the way we process its various layers of meaning has also been pointed out. Here we suggested that our natural tendency to analyze sounds in a soundscape is directly related to the way we assign specific levels of meaning to the different timbres in the same system, i.e., "sound signals", which are individual sounds that intend to communicate a particular message, like our voice in a conversation; "keynotes", which are the fundamental sounds that form the background of the sound event and are usually continuous, like the sea on a beach; "sound marks", by analogy with "landmarks", which are unique characteristic sounds for a particular place; and "foreground sounds", which refer to those that naturally tend to stand out. In this way, a relationship is established to the organization of sounds in a Soundscape proposed by Schafer (1977/1994).

The strong influence that reverberation has on the emotional perception of timbre was also evident in our interviews. The acoustic clues about space present in the chosen reverberation can help to create a more accurate mental picture of the emotional idea that the sound intends to express. Reverberation has been seen as a form of global framing of a particular emotional state, as all sounds contained within the same acoustic space/reverberation share the same acoustic clues and therefore also the same emotional valence. Furthermore, the various existing practices of adding reverberation to a sound, such as parallel or series, can directly modify its envelope characteristics, further shaping its emotional valence. It has also been suggested that the use of reverberation in

a sound tends to prolong the existence of certain harmonics in time (Marques, personal communication, 2020), therefore it can serve as a way of exacerbating a particular timbral characteristic and accentuate the emotional valence already present.

Finally, and in a surprising way, sound spatialization took one of the main roles in the phenomenon of emotional relation to timbre, as it was the most emphasized feature in the sum of all interviews in this research. Therefore, sound spatialization was explored in this research under the foundations that underpin aural architecture (Blessner and Salter, 2009), focusing on the effects that were considered fundamental by our interviewees, such as localization, directionality, and sound movement/action.

It was reiterated that sound is a three-dimensional phenomenon and therefore the three-part relationship between listener, space and sound source needs to be considered in this study, despite the infinitely complex series of acoustic and psychoacoustic events involved. For our interviewees, the spatial behavior of a sound has a direct impact on the way we perceive it. In addition to timbre, which undergoes an obvious mutation in its spectral component and envelope, localization, directionality, and sound movement/action describe the relationship of listener-space-sound source interaction and provide powerful acoustic clues that characterize and contextualize the relevance of the sound at a given moment. Thus behaving almost like a character with a backstory and context that interacts directly with the listener.

The location of the sound source in relation to the listener can evoke associations of fear, discomfort or even excitement, depending on the timbre used, just as the location of the sound source in relation to the space can evoke an infinity of meanings depending on the context and the timbre used. As a practical example, Lima (2020) recounts his show *Memorabilia* (2011), in which the audience had no visual reference about a theatre room directly in front of them, which was completely darkened. In this space, speakers were installed on several floors, including the top of the theater, which was at a much higher level than that of the seated audience. Lyrical voices were played from these speakers. As the audience had no visual perception of the sound source or the location from which it was reproduced, they quickly began to form associations and fantasize about the phenomenon, evoking an emotional meaning for that timbre that depended on the context and its spatialization. In the same way it was proposed that experiences with the directionality of the sound source can evoke feelings of instability in certain contexts, and even have the ability to intentionally focus the listener's attention, i.e., reminiscent of the 'cocktail party effect' (Farnell, 2010), it is possible that one timbre among others gains relevance when it is intentionally directed at the listener, as if someone is calling or saying your name in the middle of a crowded party.

The spatial movement of sound is considered in this study to be a necessary consequence of the overall interaction between listener and space, as this relationship is bidirectionally established.

This initiates a movement between sender and receiver, almost like a dance, in which the movement of the sound serves as yet another clue to the overall sonic message, in which the interaction of the sound with the listener and the space reveals new and evolving perspectives and rearranges the contextual meanings. (Costa, personal communication, 2020; Fernandes, personal communication, 2020). It has been suggested that the consequente timbral modulations of the sound's movement in relation to the listener or the space have the capacity to change its aural personality and/or displace it from the context, making it an instrumental force in sound design. (Tudela, personal communication, 2020; Costa, personal communication, 2020; Fernandes, personal communication, 2020)

As a final comment, our interviews also revealed a common concern about a general lack of interest or academic knowledge about timbre in artistic and scientific schools, where the classical study of more common acoustic cues such as pitch or rhythm is always preferred. This practice has made it difficult to discuss and think about the topic, making this powerful tool a forgotten part of sonic expression. (Holmes, 2011; Eerola et al., 2012). For this reason, sharing information and disseminating the importance of timbre design in sound and artistic expression is encouraged in our schools.

5.2 Future work

The present research can serve as a stepping stone for additional studies, with different methodologies (subjective tests, observational analysis, signal analysis) that can further corroborate our findings, in both qualitative and quantitative lights. There is no clear indication that working with timbre has cultural and geographical boundaries in the 21st century, but it is possible that the reality we tried to describe is intrinsically Portuguese or Iberian or Western European. Expanding like-minded studies to different locations, eventually using artists and practitioners that represent the voice of a geography or culture might yield interesting results in comparison to what has been done here. Research based on Grounded Theory always benefits from multiple levels of validation, so additional investigations with different practitioners, even in the same location, would leave a rich tapestry of information. It would also be useful to create a future database based on subjective tests with listeners with no professional relationship to sound, which could measure more accurate results about the influence of reverberation and spatialization on the emotional perception of timbre. Finally, as with all studies dealing with aspects related to Knowledge Engineering, the extracted knowledge can be applied to expert systems for an additional layer of validation, and result in tools,

software or hardware, that may alleviate the work of practitioners by adding additional abstractions that better correlate with the conceptual nature of their work.

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