Master's Thesis

Different moment, different tune – How emotional perception of music changes with the time of day

by

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Tiivistelmä – Abstract

According to the classical music tradition of Northern India, the ability of a song to induce certain emotions depends on the time of day: playing a song at the right time is said to maximise its emotional effect. Transposing this idea into a Western context, I decided to investigate this claim by combining findings in chronobiology with findings in music and emotion.

It has already been established that our mood fluctuations follow a cyclical pattern. Besides, it is a known fact that our current mood influences our ability to perceive emotions. However, no one has ever linked these elements together and studied diurnal mood variations and their effect on perceived emotions in music.

To test the hypothesis of a link between the two, I played Western film music excerpts to 36 participants at two different times, and asked them to rate the perceived emotions. The results show that sad and tender clips were rated higher on sadness and tenderness in the morning compared to the afternoon. Furthermore, the more tired the participants were, the higher was their perception of fear in angry and fearful music.

Looking at conventional medicine, chronopharmacology has already shown that the effects of a drug or the results of a medical test vary depending on when they are administered. Similarly, I believe that by adding the time factor to the planning and interpretation of music therapy sessions, their health benefits could be increased. This last point would need to be investigated further and could be the focus of future studies.

Asiasanat – Keywords

Music, emotion, time, circadian rhythms, chronobiology, Indian classical music

Säilytyspaikka – Depository

Muita tietoja – Additional information

“To everything there is a season, and a time to every purpose under the heaven”

(Ecclesiastes 3:1, King James Bible)

Figure 1. Goddess Saraswati

Saraswati is the Hindu goddess of knowledge, music, arts and science.

Hindus worship her not only for academic knowledge (education), but also for divine knowledge (enlightenment).

In the spirit of Saraswati, this Master’s thesis is aiming at overcoming the artificial divide between natural sciences and the humanities.

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Introduction

Leaving the four walls of the current world view in an attempt to improve and expand the practices derived from it, is never an easy task. Every generation is always convinced to have reached some form of undisputed or ultimate truth, only to be disproved by the next generation. Besides, spellbound by the seemingly unstoppable arrow of progress, we tend to forget that some valuable knowledge might get lost in the process. As we will see, such an unfortunate development happened to our conception of time.

The present study is all about time. More specifically, it is about the benefits that can be achieved by looking at time from a qualitative and cyclical perspective, along with the usual quantitative and linear one. Very often, modern science is isolating the objects of its interest and turning them into static systems, thus ignoring their link to the greater whole. Another consequence of this practice is a lack of understanding for the rhythmical nature of time and its effects on the system under scrutiny. However, in recent decades, a new scientific field called chronobiology has increased our awareness of the time factor.

As a student of music therapy, my natural motivation is to try and improve the current therapeutic practices. Since academic medicine has already started to reap the benefits from studying what is commonly known as biological clocks, I thought it is high time such studies were undertaken in music therapy. Obviously, before being able to develop concrete and useful applications, it is first necessary to study the effect of the passage of time on emotional processes and music perception. We already know that our current mood influences our perception of musically-expressed emotions, and also that moods are cyclical in nature. It should therefore be possible to combine the two and investigate whether our emotional perception of music changes with the time of day.

To answer that question, I decided to navigate across disciplinary boundaries and draw from many academic subjects. Thus, I will be presenting facts and ideas from disciplines as diverse as cultural history, religious studies, ethnology, philosophy, linguistics, biology, medicine, ethnomusicology, music psychology and quantitative research. I believe that offering an interdisciplinary perspective is not only more interesting, but also one important step towards bridging the gap between natural sciences and the humanities.

This work is structured in four parts. I begin with a general presentation on the concept of time, highlighting the shift that occurred in Western culture ca. 400 years ago. The second part is an overview of chronobiology and its current applications. In the third part, I look at music from a chronobiological perspective by using the time theory existing in Indian classical music. Finally, I present the findings of a music-listening experiment especially designed to test the Indian time theory in a Western context.

I. The concept of time

A. *Two different conceptions*

For the modern scientific mind, time is a stable constant that is present in the background while events unfold. It is seen as being quantitative in nature, and it can therefore be measured using specifically designed instruments. These instruments, mechanical or other, have become more and more accurate over the centuries. There is no denying that we have come a long way from the early clepsydras (water clocks) and hourglasses (sand clocks) to today's atomic clocks. However, these progresses are hiding the fact that time possesses also another aspect which is *qualitative*. We in the West used to be aware of this qualitative aspect and many cultures around the world are still very cognisant of it. Our conception of time started to change when modern science became dominant at the end of the Renaissance, shifting the emphasis from the invisible essence of things to their visible and objective form.

Today, it has become very difficult for us to imagine time as being more than just a measurable quantity. This fact can be seen in our usage of the word "time". Indeed, time is mainly something that we have, spend, save or waste. Under those circumstances, how should we understand the idea of time having also a qualitative dimension? One way to explain the double aspect of time is to look for example at the Greek and Chinese languages.

In ancient Greek, there are two words to talk about time: *chronos* (χρόνος) and *kairos* (καιρός). *Chronos* is the linear, objective time that can be measured, and we find this root word in many English words (e.g. chronology, chronometer or chronicle). I will not go into more detail here, since this is the equivalent of our modern concept of time. *Kairos* however is an unusual and interesting concept. When ancient Greeks talked about *kairos*, they referred to the right or opportune moment in time. The idea is that each moment is the bearer of certain possibilities that are related to the quality of that specific moment. Since this exact constellation of possibilities may not reoccur again, it is important to seize the opportunity and start an action at the right time (Sipiora & Baumlin, 2002).

In ancient Greece, *kairos* was personified as a god bearing the same name. He is depicted as a young man with wings on his back and heels, and a long tuft of hair on his forehead (see Figure 2). Always in motion and moving as fast as the wind, Kairos has to be grasped by the hair, otherwise he escapes. The fact that the back of his head is bald means that once he has passed us, it is too late to catch him. Furthermore, Kairos is usually seen balancing a scale on the edge of a razor blade, which represents the unstable and ever-changing qualitative aspect of time. To summarise, the god Kairos represents the fleeting moment that once missed, will never return in the exact same form and with the exact same quality (Franz, 1978).

At this point, I would like to draw the reader's attention to the quote found at the very beginning of this work:

"To every thing there is a season, and a time to every purpose under the heaven: a time to be born and a time to die; a time to plant and a time to pluck up that which is planted..." (Ecclesiastes 3:1, King James Bible).

In the ancient Greek version of this biblical passage, the word used for “time” is not *chronos* but *kairos* (Sipiora & Baumlin, 2002). The English translators tried to render this idea by using the wording “a time to”. This is a very elegant solution, given the fact that modern English only possesses one word for “time”.

Figure 2. The Greek god Kairos

Referring to the Bible and to ancient Greek might give the impression that the idea of *kairos* has been long obsolete in our Western culture. However, this is far from the truth. Indeed, this idea was still present in Europe at the turn of the 17^{th} century, as can be seen in the works of Shakespeare for example. In his play *Julius Caesar,* he expresses the consequences of missing the *kairos* moment as follows:

“There is a tide in the affairs of men
Which, taken at the flood, leads on to fortune;
Omitted, all the voyage of their life
Is bound in shallows and in miseries.”
(Shakespeare, 1998, p. 292)

Interestingly enough, the word “tide” in English can refer to the movement of the ocean with its highs and lows, but it can also mean “a moment in time” (as in Yuletide, another word for Christmastime). More specifically, the word “tide” might also refer to a *critical* moment in time, usually a turning point of some sort. Shakespeare nicely describes this idea with the words “a tide […] taken at the flood”, which is the moment when the water is rising, between a low tide and the following high tide. What is even more interesting is that the archaic meaning of “tide” is actually a favourable occasion or an opportunity (‘Tide’, n.d.). Unfortunately this meaning has now become obsolete, making a direct translation of *kairos* very difficult.

Turning our attention to *shi* (時), the Chinese word for time, we find a very similar concept to *kairos*. Sadly enough, when translated by the English word “time”, *shi* loses all its depth and nuances. The original meaning of *shi* is not “time” as the modern Westerner understands it, but “timeliness” or “seasonality”. For the Chinese mind, time and space are always connected, forming an inseparable bundle. In other words, far from being a neutral or abstract parameter, time is always seen as interacting with a certain space in a certain way. Therefore, *shi* also refers to doing something at the appropriate time, with the idea that only the appropriate time will allow an action to be successful. Marie-Louise von Franz describes *shi* as “a circumstance favourable or unfavourable for action” (Franz, 1978, p. 7).

As we can see, both the Greek and Chinese conceptions of time have in common the idea that an action can only be successful if it is performed at the right moment. What is then the “right moment”? It is the moment that has the same quality as the action to be performed. Finding the proper match is deemed extremely important, because an endeavour or enterprise is said to develop according to the nature of the moment when it is initiated. Seen from that perspective, it is of the utmost importance to be able to establish the quality of any moment in time. Quite naturally, cultures with a predominantly qualitative approach to time have all developed highly sophisticated methods to achieve that goal. This is why the Babylonians invented astrology or the Chinese created the *I Ching*, a numerical divination system. Traditionally, it was the task of the priest or the astrologer to master those methods and determine the best moment to marry the princess or attack the neighbouring kingdom. Far from being limited to ancient times, the art of astrology for example was being extensively practiced at every European court until the end of the Renaissance, with famous figures like John Dee advising Elizabeth I or Nostradamus advising Catherine de Médicis (Kenton, 1974).

Before proceeding further to the next part, I first need to dispel a common modern misunderstanding concerning astrology. Astrology is not, and has never been, the study of mysterious planetary influences on earthly events. It might come as a surprise to many, because this is usually the way astrology has been described, even by those who use it professionally. However, real astrology is based on a completely different set of principles (see Frawley, 2001, chap. 7). These principles are rooted in the world view of those people who invented astrology, and the idea of planetary influences could not possibly have been part of that world view. Let me explain why.

In order to talk about influences, one has to presuppose the existence of a causal link between two things, where one has an effect over another. This way of thinking is the very basis of modern science and it has become the only way most Westerners will perceive and analyse the world around them. However, until the end of the Renaissance, people’s world view was dominated by the ideas of analogy and resemblance, not causality. As explained by Foucault (2001), “Up to the end of the sixteenth century, resemblance played a constructive role in the knowledge of Western culture. It was resemblance that largely guided exegesis and the interpretation of texts; it was resemblance that organized the play of symbols, made possible knowledge of things visible and invisible, and controlled the art of representing them" (p. 19).

When thinking analogically, one creates links between things by looking at what these things have in common, usually a theme or an idea. One would for example say that black (colour), a raven (bird), a prison (place), teeth (body part) and renal calculi (disease) all bear the signature of the same principle, which could be defined by the words "structure", "limitation", "obstruction", “dark”, “death” or "time". These words can all be associated with the characteristics and attributes of the Roman god Saturn. Our forefathers would therefore say that black, a raven, a prison, teeth and renal calculi are all the result of the Saturn principle expressing itself on different levels of reality (the level of colours, birds, places, body parts and diseases). As we can see, the nature of this link is not causal but symbolic. In a world seen from the point of view of analogies, things are not causing each other, they just happen simultaneously. If we follow this logic to the end, it means that, in theory, if someone would remove the Saturn principle, then all its forms of expression would stop to exist, immediately and completely (just like when selecting a column in Excel and pressing Delete). This means that whatever happens to the principle of Saturn automatically affects all its different manifestations in the material world.

Since “Saturn” is in fact an archetypal idea, it is impossible to observe it directly. One can only observe it indirectly, through its numerous forms of expression. Now, when our forefathers wanted to figure out what was currently happening to the Saturn principle, they only needed to observe one of its manifestations, on any level of their choosing. They knew that whatever would happen on that level would also happen on all the other levels related to Saturn. Examining one entity to understand another entity was basically a deductive shortcut derived from their analogical world view.

We are now getting closer to the real nature of astrology. Indeed, if we apply the same principle when looking simultaneously at the earth (microcosm) and the sky (macrocosm), then whatever is connected to the Saturn principle here on Earth will logically behave like its celestial counterpart, namely the planet Saturn. It is important to understand that the celestial object known as Saturn was only named like this because the Ancients thought it was the ideal manifestation in space of “limitation”, “obstruction” and “time”. They came to this conclusion because this particular planet has the slowest orbital period of all the planets that can be observed with the naked eye. Indeed, as seen from Earth, it takes almost 30 years for Saturn to return to its original position, compared to 3 months for Mercury or 7.4 months for Venus (see Figure 3 and Table 1).

Having said all this, we see that astrology should in fact be defined as the art of understanding what is happening on Earth by using the sky as a celestial mirror. To be very accurate, we are dealing in fact with a double mirror that can be contemplated in either direction: the sky is echoing the earth, and at the same time the earth is echoing the sky. Adding now the idea of time quality, a more complete definition of astrology would be the art of determining the quality of any moment in time by looking at planetary movements (Frawley, 2001).

This brief explanation hopefully clarified that astrology was used by the Ancients as a tool to explain reality and to make predictions, just like modern science is used to explain reality and to make predictions. Both are born out of the same need to find answers and make sense of the world. The only thing that has changed is the philosophical and theoretical framework, since each time period is always dominated by a specific world view. What has certainly not changed is humans’ eagerness to practice science in the broad sense, in other words to develop a system of knowledge that can explain reality.

Unsurprisingly, our Western neglect for the qualitative aspect of time coincides with the abandonment of a world view based on analogy for a world view based on causality. However, as I have already said, it has not always been like this. A legacy of this former world view can still be seen today in the names of the days of the week, although very few people are actually aware of this.

B. *Names of the days of the week*

The names of the days of the week belong to the most common words in every language. We use them on a daily basis, but most of us are oblivious to the origin and cultural significance of these names. I would like to briefly explain how these names came to be, because it will serve as proof that we used to have a strong qualitative conception of time.

When looking at how various languages around the world have named the days of the week, we notice the existence of two main approaches. One approach is to name the days after planets. This is the case of Germanic and Romance languages, most Indian languages, and many languages spoken in East and South East Asia (e.g. Japanese, Korean, Thai and Tibetan). The other approach is to use numbers ("first day", "second day" etc.). This is the case of Slavic and Semitic languages. Then there are languages mixing both planets and numbers (e.g. Icelandic) and languages that have evolved from a planetary to a numeric naming system (e.g. Chinese and Portuguese). The following explanation is based on the Greco-Roman tradition and is therefore valid for the European languages following a planetary naming system.

As previously explained, the main purpose of astrology is to determine the specific quality of any moment in time. In order to do so, the astrologer will look at the movement of celestial bodies and produce astrological charts, also known as horoscopes. The word "horoscope" comes from the Greek *hora* ("hour") and *skopein* ("to look"). In other words, the astrologer is "looking into the hour" and trying to determine its quality. However, the hours in question are not exactly the same as the hours indicated by a modern clock.

From the point of view of astrology, a day is made of 12 hours of daylight and 12 hours of darkness. One astrological daytime hour is therefore equal to one twelfth of the time between sunrise and sunset. The same approach is used to calculate the length of one night hour. As a result, daytime and night-time hours are unequal and the length of one hour changes every day (unless one is living on the equator, where day and night are always of equal length). An interesting legacy of this time measurement practice can be found in the expression "to do something at the eleventh hour", meaning at the last minute. Indeed, at the eleventh (daylight) hour one has to hurry, because night is about to fall.

After our forefathers had done this, they would associate to each of these hours one of the seven planets known in the classical world. The idea was that each hour was supposed to have the quality and characteristics of one planetary principle. The succession of these principles during the course of one day was following the order of the planets as described in the Ptolemaic system. This order is based on the relative orbital period of these planets (the time it takes them to return to their original position as seen from Earth). The planets with the fastest orbital period come first, and the slowest planets are placed at the end. The order of the planets in the Ptolemaic system is shown in Figure 3, along with their orbital period (Table 1).

Figure 3. Cosmological model according to Ptolemy

Table 1. Order of the planets in the Ptolemaic system

		Orbital period
♄	Saturn	29.4 years
♃	Jupiter	11.9 years
♂	Mars	1.9 years
☉	Sun	1 year
♀	Venus	7.4 months
☿	Mercury	2.9 months
☽	Moon	30 days
(♁)	(Earth)	

Orbital (sidereal) period from NASA (Williams, n.d.)

The planetary principles were assigned to each hour by moving downwards in the list and then repeating the list, so as to cover 24 hours. To use an astrological term, each hour was said to have a ruler, which is another way of saying that the qualities of a certain planetary principle are dominant during that time.

Complexifying the system a bit further, the Ancients not only thought that each hour has a certain quality, but also each day has a specific ruler. This resulted in each hour having actually the qualities of its own ruler *combined* with the qualities of the daily ruler. In other words, a “Venus hour” on a “Venus day” was supposed to be more Venus-like than on a “Mars day” for example.

The planetary principle that was ruling each day was considered to be the planet ruling the first hour of daylight. As a result, the whole day became named after that planet. Table 2 illustrates the passage from Saturday (Saturn-day) to Sunday (Sun-day), with “1” being the first hour of daylight. As we can see, this first hour is ruled by Saturn on Saturday and by the sun on Sunday. If we keep on counting in the same fashion, we will notice that the 25th hour after a Sun-hour is a Moon-hour, which is the first daylight hour of Monday (Moon-day).

Table 2. Sequence of the planetary hours

♄	♃	♂	☉	♀	☿	☽	♄	♃	♂	☉	♀	☿	☽	♄	♃	♂	☉	♀	☿	☽	♄	♃	♂	☉
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	1
↑																								↑
Saturday																								Sunday

In medieval times, many sophisticated clocks were designed to display both the even ("normal") hours and the uneven planetary hours, calendrical information, the position of the planets in the zodiac, and sometimes even the hourly and daily rulers. One such example is the astronomical clock of the Münster cathedral in Germany, built during 1540-43 and still working today. Running vertically on each side of the clock are moving panels displaying the hourly rulers for the current day. Some of these panels are visible in Figure 4, where we can read for example "JUPITER REGIT IN 16 HO" (Jupiter rules the 16th hour), followed by "MARS REGIT IN 17 HO" etc. The fact that such highly complex clocks were installed in many public places across Europe during the Middle Ages proves that the information they displayed was useful and important to people in their daily life.

Figure 4. Astronomical clock of the Münster cathedral, Germany

The modern denomination "astronomical clock" is actually misleading, because it hides the astrological purpose of these clocks. Reducing them to mechanical astrolabes is just another illustration of the difficulty we have to understand the world view that preceded ours, where no distinction was made between astrology and astronomy.

The astute reader will already have noticed that in the English language, not all the weekdays seem to bear the name of planets. Indeed, those planetary names are much more visible in French or Italian for example. In English, an obvious planetary association is only possible with Saturday, Sunday and Monday. So what about Tuesday (French "mardi", Mars), Wednesday (French "mercredi", Mercury), Thursday (French "jeudi", Jupiter) and Friday (French "vendredi", Venus)?

As I said before, what mattered to the Ancients were the qualities and attributes of the gods associated with these planets, not the planets themselves. A bit of etymology will show that the modern English names actually refer to Germanic, Nordic or Anglo-Saxon gods that have similar attributes to their Roman counterparts.

- Tuesday: Old English *tīwesdæg*, from Tīw, god of war.

- Wednesday: Old English *wōdnesdæg*, from Wōden, Anglo-Saxon god escorting newly deceased souls to the afterlife.
- Thursday: Old English *thunresdæg*, with *thunor*, thunder, from Old Norse *Thōrr*, Thor, the hammer-wielding god of thunder and lightning.
- Friday: Old English *frīgedæg*, from Frigg, the Germanic goddess of love.

(*Merriam-Webster online dictionary*)

Although the names are different on the surface, they actually refer to deities that have similar attributes:

- Tīw / Mars: war and heroic glory
- Wōden / Mercury: escorting of dead souls to the underworld
- Thor / Jupiter: thunder and lightning
- Frigg / Venus: love and fertility

In other words, although the people of Europe are culturally and linguistically diverse, we find the same fundamental logic in their ways of naming the days of the week. What is even more remarkable is that if we go as far as India or Japan, we will encounter exactly the same logic: the Hindi and Japanese names of the aforementioned planets are also used to name the days of the week, in exactly the same order.

To summarise, we in the West used to think that the quality of a day's first daylight hour was so important that we deemed it necessary to call the entire day after that quality. This is not just a trivial anecdote. It is an illustration of the gap separating our current world view from the one of our forefathers. Calling this gap huge is certainly no understatement.

It is important to realise the magnitude of the paradigm shift that occurred 400 years ago in Western culture. After all, this is quite a short time on the scale of human history, yet these four centuries have been enough to completely estrange us from a world view based on essence, analogy and symbolism. Moreover, our current lack of understanding for anything non-rational, non-causal and non-material is actually limiting our understanding of the world and of other cultures, past and present. I would like to illustrate this last point with a discovery made by the Swiss psychologist Carl G. Jung while visiting East Africa.

In 1925, Jung spent several weeks with the Elgonyi, a tribe living on the slopes of Mount Elgon, at the border between Kenya and Uganda. Every morning at sunrise, the Elgonyi would come out of their huts, spit in their hands and hold them up towards the sun. Jung's first thought was that he was witnessing some form of sun worship. However, he also noticed that they called the sun *mungi* (God) in the morning, but not during the rest of the day. Intrigued, he asked the elders whether the sun was God. They simply laughed at him, without giving him any satisfactory explanation. It took Jung three weeks before he understood the nature of the Elgonyi's sun offering ritual. They were not worshiping the sun as such, but *the moment of sunrise* (Jung, 1990).

This story has two implications. First of all, it describes yet another culture for which the moment of sunrise is very important. Europeans named the day after the quality of that moment, while the Elgonyi performed a daily offering ritual. The practices are different, but in both cases they illustrate a similar importance given to that specific moment. Secondly, this anecdote raises the question of how often Western anthropologists or journalists mistakenly described indigenous cultures as practicing sun worship, when they were in fact celebrating the importance of certain moments in time. If someone as open-minded and well-versed in world cultures as Jung made this initial mistake, it surely must have happened to many other people. One example is a recent article from BBC News, entitled “Archaeologists make new Stonehenge 'sun worship' find” (‘Stonehenge new “sun worship” find’, 2011). When reading the article, one notices that the story is actually about two newly-discovered pits that are aligned towards midsummer sunrise and sunset. Characterising this finding as a case of “sun worship” is therefore incorrect, since our ancestors were actually interested in marking a moment in time and not in worshipping the marker.

The consequences of such misunderstandings should not be underestimated. Indeed, worshipping a moment in time is much more subtle, spiritual and sophisticated than worshipping concrete, physical objects “out there”. Humans came to this realisation a long time ago. The difference between form and essence is already established in the Old Testament, where the first two commandments are explicitly criticising all forms of idolatry (Exodus 20). It is the same in Buddhism, where followers are told not to worship statues of the Buddha, but to use them as mind-focusing tools in the process of connecting with the eternal Buddha-Nature (Rahula, 1974). In other words, by erroneously reducing certain cultural practices to sun worship or general idolatry, we are simplifying and belittling practices that are actually profound and elaborate.

We are now reaching the end of this journey across various cultures and time periods, whose aim was to explain and illustrate the double nature of time, with an emphasis on its qualitative aspect. To avoid any misunderstanding, I would like to clarify one thing: there is nothing wrong with measuring time objectively. The quantitative aspect of time has proven to be very helpful and has now become a crucial part of our lives. However, since time has two aspects, by focusing only on one of them we are missing half of the story. I believe the qualitative and quantitative aspects of time are not mutually exclusive, quite the opposite: they are actually complementary. If this is true, then our Western culture would actually hugely benefit from looking at both aspects simultaneously. We could for example start by asking ourselves very simple questions like, “Is every moment really the same?” or, “Should we do things any time we want?”

In case we should not be willing or able to transpose ourselves into another world view or mindset, it is actually possible to find concrete answers within the Western cultural framework. Indeed, a new scientific field emerged in the 20th century, whose focus is on biological changes across time. This field is called chronobiology, and it will be the main subject of the next part.

II. Chronobiology

Chronobiology is the expression of a modern-day paradox concerning the nature of time. Although we tend to see time as being mainly linear, it is hard to dismiss the fact that many phenomena are cyclical and seem to repeat endlessly. Some of the most obvious observations would be the day and night cycle, the phases of the moon and the cycle of the seasons. In fact, the more we look at the natural world, the more cycles we will find, some very short and some others very long. These cycles, applied to living organisms, are the main focus of chronobiology.

A. *Chronobiology in plants*

It is nowadays an undisputed fact that every living thing has within its organism biological clocks that regulate and synchronise its activity to the time of day and the seasons (Reinberg & Smolensky, 1983). However, before they became widely studied in human beings during the 20th century, cyclical biological rhythms had already been observed for a very long time in the natural world, especially in plants. Therefore, plants shall be the starting point in this explanation of chronobiology. In so doing, it will also be easier to understand chronobiological concepts when applied to humans.

Anybody familiar with gardening or farming knows that for each type of seed, there is an ideal moment to plant them. If we sow at the wrong time, the plants and crops will grow poorly or not grow at all. This is because each plant species is adapted to a specific season and has its own flowering time. When growing in the wild, plants synchronise with each other and follow their natural rhythm automatically. However, every time we decide to intervene and plant certain seeds in a controlled fashion, we need to know and respect these cycles if we want to be successful in our horticultural and agricultural efforts.

What is true on the time scale of a year is also true on the time scale of a day. Indeed, flowers open and close periodically, but not all at the same time. In fact, depending on the species, each type of flower will have a specific opening and closing time. Such a time-shifted synchronisation has two advantages. First of all, it allows pollination by insects to happen throughout the day, and not only at a single moment. Since many flowers only stay open for a short while, if all the flowers would open and close simultaneously, it would create chaos and competitive pressure among the insects. Secondly, since each type of flower is favoured by specific insects, it is much more efficient and energy-saving for the flower to coordinate its opening with the arrival of “its” insects. This also proves efficient for the insects, since they do not need to search for the pollen of interest when it is not available.

Based on that knowledge, the Swedish botanist Carl Linnæus (1707-1778) created the concept of the “flower clock”, or *Horologium Florae* as he called it. His idea was to create a dial-shaped flowerbed that could serve as a clock (see Figure 5). By planting flowers in 12 segments according to their opening and closing time, it should be possible to estimate the time of day just by looking at which flowers are currently open (Blunt, 2001).

Figure 5. Flower clock as designed by Carl Linnæus

In reality, implementing this idea is very difficult. To begin with, the choice of suitable flowers is limited to the equinoctial type, meaning flowers that have a fixed opening and closing time. A great majority of flowers are not of this type. Usually, plants are sensitive to many environmental factors, such as humidity, temperature, amount of daylight and behaviour of insects in the area (Fründ, Dormann, & Tscharntke, 2011). All these factors influence in an unpredictable way the opening and closing patterns. Even the rhythm of equinoctial flowers is only predictable locally, because it will vary across latitudes. So the list of suitable plants and their opening times established by Linnæus is only valid for places located 60 degrees north, which is the latitude of the Swedish town of Uppsala. Besides, in order to remain accurate, a flower clock would have to be replanted every few months with corresponding seasonal flowers.

As we can see, Linnæus' idea is more theoretical than practical. However, talking about plants and introducing the flower clock allowed us to touch upon two fundamental notions at the heart of biological rhythms: *synchrony* and *interdependence*. I will now elaborate on these two ideas.

It is important to keep in mind that synchronous does not necessarily mean simultaneous. To be able to talk about synchrony, it is enough if the phases of recurring events keep to the same *period* (Strogatz, 2004). The period is akin to the beat that musicians keep in their head when they are not playing. When it is again their turn to play, they are able to come in exactly at the right moment, without disrupting the harmony of the pre-existing music. In other words, whether they are currently playing or not, musicians always remain synchronised with the rest of the band or orchestra.

Interdependence is a direct consequence of synchrony. Indeed, by definition synchrony cannot occur in isolation. It requires constant contact or interaction between the actors involved. Moreover, for the system to properly function as a whole, each sub-element must diligently play its part and remain in lockstep with the others. If one sub-element changes its oscillation period, either the whole system collapses or the other elements adjust to these changes and find a new state of equilibrium and harmony. This point can again be illustrated with a musical example. If during band practice a musician suddenly changes the tempo or does a mistake, there are usually two possible outcomes: either the other band members immediately stop playing (collapse), or they ignore the mistake for now and/or adapt to the new tempo (adjustment). Either way, changes in the oscillation of one component always has repercussions on the system as a whole. This is a very important aspect of chronobiology, as it is connected to the health and well-being of an organism.

The next legitimate question concerns the referential used by a system to remain in sync. How does each oscillator know which period it should follow? In other words, is there some kind of pacemaker? The answer is yes, but it all depends on the type of biological rhythm we are looking at. Some rhythms are completely endogenous, meaning that they rely on an internal pacemaker and are unaffected by outside events. However, a great majority of biological rhythms are exo-endogenous, which means that the internal pacemaker is periodically reset by one or several external cues (Reinberg & Smolensky, 1983). The most common external cue is the day and night cycle, which is why chronobiologists are mainly concentrating on what they call circadian rhythms (from the Latin *circa,* around and *dies,* day). Of course, longer and shorter cycles do exist, e.g. circannual rhythms (one year) or ultradian rhythms (less than 24 hours). Considering the simultaneous interplay of these various rhythms would be far too complex, which is why the rest of this study will focus on circadian rhythms. They are also those that have been the most studied in the past and are therefore the best known by chronobiologists.

B. *Chronobiology in humans*

When it comes to humans, all the principles and mechanisms described above apply as well, except that everything is much more complex. Whereas each plant was a soloist, we are now dealing with an entire orchestra made of many sections and individual players. The individual players would be the cells, and they are regrouped in sections according to their function, each section being the equivalent of a specific organ or physiological process. Each organ has a phase of high activity and of rest, but not at the same time (cf. the time-shifted opening and closing patterns of flowers). Similarly to musicians keeping the tempo in their head, each organ follows its own rhythm while keeping the general rhythm of the body. Just like in a symphony orchestra, this highly complex biochemical symphony can only be sustained and coordinated with the help of a conductor. In the case of the human body, this “master clock” is called the suprachiasmatic nucleus (SCN). It is a small cluster of brain cells, not bigger than a grain of rice. It is located right above the optic chiasm, which is the place in the brain where the optic nerves cross (hence the name “suprachiasmatic”). This location is very strategic, because it enables the SCN to receive sunlight information directly from the retina. It then uses that information to synchronise the body’s internal rhythm with the day and night cycle (Strogatz, 2004).

This quick overview summarises the most important features of our biological clocks. Naturally the story does not end there. So far, we have described how cells synchronise inside each organ, how organs synchronise with each other, and how our body is kept in synchrony with the cycles of nature. If we add one more level, we can say that we are actually participating in a giant symphony that involves every living thing on this planet. Seen from that perspective, our biological clocks are part of a collective effort to promote life, in an optimised, healthy and sustainable form. Inversely, any disruption of these rhythms causes imbalances, which will sooner or later lead to sickness if the balance is not restored.

The study of circadian rhythms has led chronobiologists to discover countless physiological processes that follow a daily cycle, e.g. brain wave activity, hormone production, body temperature, blood pressure and alertness. Figure 6 shows some important circadian rhythms in human physiology.

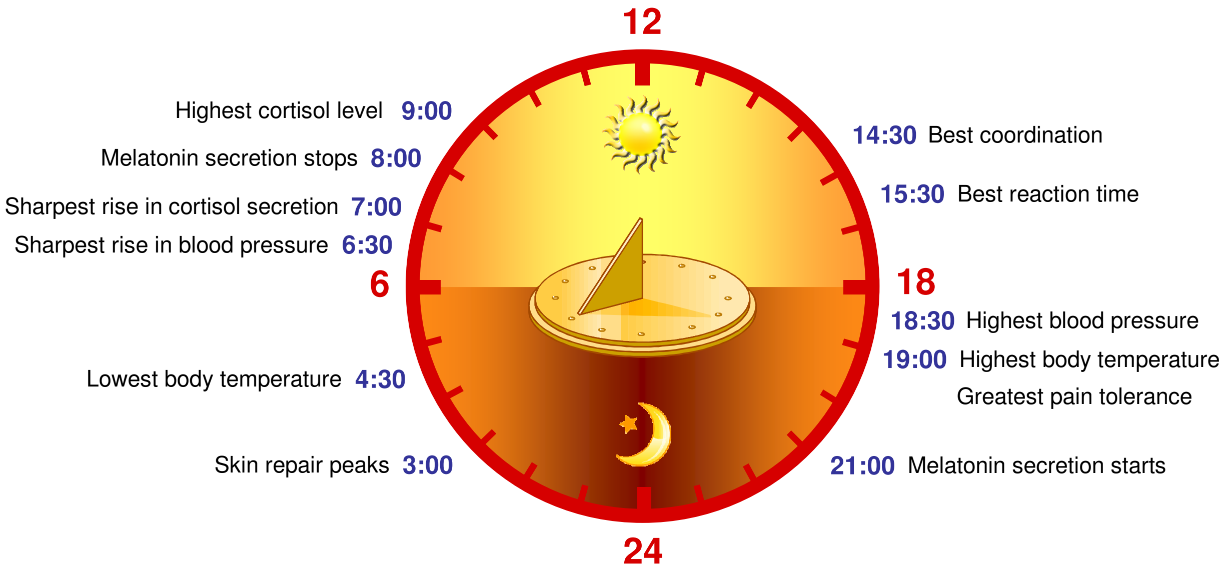

Figure 6. Daily rhythms in human physiology

The times mentioned in Figure 6 might give the impression that this information is absolutely true for everybody, when there are of course individual differences, depending for example on gender and age (Smolensky & Lamberg, 2001). Hence, any specific time given in chronobiology should only be regarded as an approximation or a strong indicator. Nevertheless, these indicators are generally true for most people and can therefore be used to derive valid conclusions about human biology, as well as useful therapeutic interventions.

Among the physiological processes shown in Figure 6, two have proven to follow a very reliable and regular circadian rhythm: body temperature and production of the stress hormone cortisol. For this reason, they are often used as a referential in chronobiological studies (Klerman, Gershengorn, Duffy, & Kronauer, 2002). Researchers were, for example, surprised to discover that a person's body temperature cycle is unaffected by food intake, physical activity or fever. Indeed, regardless of whether test subjects eat small portions at regular intervals or nothing at all, have some physical activity or are kept in bed all day, and have fever or not, their temperature rhythm remains absolutely constant (Palmer, 2002). In the case of fever, it will only affect the amplitude of the cycle, meaning that a person's fever peak will correspond to the body's natural temperature peak (around 7 pm). Inversely, fever will be lowest early in the morning, when body temperature is normally lowest.

Another noteworthy feature of our biological rhythms is the way these rhythms regulate our sleep-wake cycle. Looking again at Figure 6, we see that in the evening, the production of melatonin starts, sending the signal that it is time to sleep. In the morning, blood pressure and cortisol production rise sharply, preparing our body to wake up. Shortly after we have woken up, the production of melatonin stops. Unsurprisingly, research has established that the quality of our sleep is best if we sleep when we are meant to, meaning during the hours of melatonin production (Smolensky & Lamberg, 2001). Of course, it is also possible to sleep during the day, but we will then recuperate much less because of the poorer sleep quality. In the long run, a sleep pattern out of phase with our circadian rhythms can have serious health consequences, for example chronic fatigue, depression and digestive disorders. Public health studies have shown that shift workers are very much affected by these problems (Smolensky & Lamberg, 2001).

Because of these circadian rhythms, many diseases also display a cyclical pattern. As people suffering for example from asthma very well know, their breathing is most difficult at night. This is because the constriction of the air passageways in the lungs follows a daily rhythm and is greatest between midnight and 8 am. People with asthma have the same rhythm as healthy people, except that in their case, the constriction is much more pronounced. To make matters worse, the production of histamine (causes lung constriction) and adrenaline (helps keep the lungs open) both follow a circadian rhythm that is unfavourable to asthmatics. Indeed, at 4 am histamine production is highest, whereas adrenaline production is lowest. As a result, asthma attacks happen 100 times more often between 4 am and 6 am than at any other hour of the day (Smolensky & Lamberg, 2001). Another example would be heart attacks and strokes: they occur much more often in the morning after waking up, when the body experiences its sharpest rise in blood pressure and cortisol secretion (Palmer, 2002).

As we can see, chronobiology confirms what the Ancients discovered intuitively, namely that there is a specific time for everything. Interestingly enough, the Bible passage quoted earlier ("a time to be born and a time to die…") has proven to be literally true. Indeed, hospital statistics reveal that there is a peak in natural births around 4 am and a peak in natural deaths around 5 am (Palmer, 2002). So even if births and deaths can of course happen any time, we seem to be biologically predisposed to enter this world and leave it in the small hours of the morning.

Given all the information presented above, the following statement will come as no surprise: the way we absorb and metabolise food or other substances is not constant but cyclical. One example among many would be alcohol metabolism. Between 10 pm and 8 am, the liver and the stomach dramatically slow down the speed at which they break down alcohol (Palmer, 2002). As a result, if people keep drinking steadily after 10 pm, most of the alcohol will stay in their system until the next morning, which is the reason for hangovers.

The same principle applies to medication: drugs are absorbed in different ways and at different speeds depending on when they are taken. Such knowledge obviously has some very useful and practical applications. It is indeed possible to use chronobiological knowledge in order to optimise pharmacological treatments. The medical field studying how the effects of drugs vary with biological timing is called chronopharmacology.

C. *Medical applications*

1. Chronopharmacology

Despite many decades of research and multiple lines of evidence, awareness of chronobiology is still low in the medical world and among the general public. This becomes quite obvious when we look at our own medical history: whenever we are prescribed medication, the doctor typically tells us to take it three times per day, no matter what kind of drug it is or what kind of disease we have. Perhaps this is the easiest way, but it is certainly not the best way. Indeed, as shown in chronopharmacology, the time we take medicine matters. By properly timing the intake of medicine, it is possible to maximise its benefits while minimising its side effects.

Maximising the benefits is directly linked to the amount of time a drug remains effective. For certain types of drugs, this amount of time can differ dramatically depending on the moment of intake. Let us look for example at antihistamines, which are drugs commonly used to provide relief from allergic reactions. Research has shown that antihistamines of the cyproheptadine type will remain effective for 16 hours when taken at 7 am, but only eight hours when taken at 7 pm (Palmer, 2002). Combining this information with knowledge of when certain symptoms get worse makes it possible to time the intake so that the drug will be available in our system when it is the most needed.

A recent pharmacological development aimed at better achieving the desired timing is called controlled-release drug delivery. The idea is to control when and how fast a drug is being absorbed. This is achieved by embedding the active ingredients into specially designed containers (usually tablets or capsules). These containers will dissolve only after a certain time, or offer continuous release of small amounts over a long period of time. Such drug delivery mechanisms are obviously very useful to prevent heart attacks for example, since we know that they happen mainly in the morning. The appropriate medication can now be taken before going to bed, and it will be released into the bloodstream the next morning, while the person is still sleeping.

The second aim of chronopharmacology is to minimise the unwanted effects of drugs. Indeed, while it is impossible to get the wanted effects without the side effects, it is at least possible to minimise these side effects by taking into account the time factor. It is well-known that aspirin for example irritates the stomach because it damages the stomach lining. Less widely known is that the amount of damage depends on the time aspirin is taken. Taking aspirin at 10 am causes on average twice as much damage as it does at 10 pm (Moore & Goo, 1987). People who routinely take one aspirin every one or two days to keep their blood thin could therefore choose to take it in the evening if they want to limit stomach irritations.

2. Diagnostic tests

Another medical application of chronobiology concerns the design of diagnostic tests. Indeed, it is now clearly established that the time of the test can affect the result (Smolensky & Lamberg, 2001). Taking this information into account is crucial to avoid wrong diagnoses. Wrongly calibrating a test can create a lot of false positives or false negatives. Taking the illustration of the diabetes test will serve as a good example.

Type 2 diabetes is a metabolic disorder where the hormone insulin becomes less effective at lowering blood glucose levels. This disorder has reached epidemic proportions in the developed world, prompting the need to routinely test people. When the test for type 2 diabetes was originally introduced, people would typically take it in the morning. As the amount of people needing to be screened increased, the test started to be administered also in the afternoon. Then something odd happened: doctors noticed that much less people tested positive in the afternoon. The explanation is that the blood glucose level used as a cut-off point to declare someone diabetic was originally decided based on morning measures (125mg/decilitre). The problem is that our blood glucose level is not constant but cyclical: it is highest in the morning and lowest in the afternoon. Nowadays, this information is used to adjust the cut-off point according to the time of day (Palmer, 2002).

This overview of chronobiology and its current applications provides strong evidence to support the idea that not every moment in time is the same, even if we tend to think so. Although chronobiology does not directly touch upon the more abstract or spiritual aspects of time as a quality, it shows very convincingly that there is indeed a best moment or a pre-programmed moment for all things biological. Furthermore, we saw how chronobiological knowledge can be used to optimise our health and the efficacy of pharmacological treatments. Could the same idea be applied to other forms of therapy, for instance music therapy? To answer this question in a satisfactory manner, it is best to first identify the main mechanism of action of music therapy and then see if it might be affected by the time of day.

III. Circadian rhythms and music

A. *Western music therapy*

Music, because of its aesthetic and symbolic qualities, is the medium of choice for a wide array of therapeutic approaches that are commonly regrouped under the umbrella term “music therapy”. This can be somewhat confusing, because the term in itself does not give any indication as to the actual method used by the therapist. However, what all these methods have in common is a psychotherapeutic dimension, where emotional and psychological issues are verbalised at some point during the session.

The way music is used and how psychological issues are addressed depends largely on the therapist’s theoretical orientation. Because Western music therapy leans strongly on psychotherapy, both fields show the same level of diversity. In behavioural music therapy for example, the therapist will use music to reinforce appropriate behavioural patterns and reduce negative or unwanted ones. In Europe, music therapy uses predominantly the psychodynamic and humanistic frameworks, whose core concepts are taken from sources as diverse as developmental psychology, Freudian psychoanalysis, object relations theory and transpersonal psychology (Wigram, Pedersen, & Bonde, 2002). As we can see, the theoretical foundations of music therapy are manifold.

When it comes to the specific use of music, there are, broadly speaking, two main approaches: active music therapy and receptive music therapy. In active music therapy, the focus is on music making. Clients are encouraged to express themselves musically in order to explore their thoughts, memories, emotions and inner conflicts. The music can be pre-composed or improvised. The therapist is usually playing together with the client, thus creating a shared musical experience. This phase of musical expression is typically preceded and followed by a more cognitive phase, where relevant points are verbalised and processed.

In receptive music therapy, the focus is on music listening. This can take various forms depending on the method. The client might listen to his/her favourite recorded music, or the therapist might play or sing to the client. In Guided Imagery and Music (GIM), the client is listening to a carefully selected programme of classical music while in a slightly altered state of consciousness. Under the guidance of the therapist, the client explores his/her inner world and shares the metaphoric imagery that arises. What all these receptive methods have in common is that music listening always serves as a starting point for the therapeutic dialogue (Wigram et al., 2002).

It is necessary at this point to clarify a few aspects concerning Western music therapy. Some therapists regard music as having intrinsic healing powers and administer it the same way a physician might administer a pill. This is the case of all the methods related to sound healing, e.g. Tibetan singing bowl therapy. Although these methods certainly have their merits, they are not strictly speaking part of what is called music therapy in the West. As I have just explained, the Western tradition is to combine music with some form of psychotherapy. This is why Bruscia (1998a) for example prefers using the term “music psychotherapy”. Consequently, music (psycho)therapy always requires the simultaneous presence of three elements: a client, a therapist and music. If one of these elements is missing, it is no longer music therapy. In other words, listening to a CD at home or playing in a band is not music therapy, even if these activities may contribute positively to our well-being.

Given the diversity of models and methods, is it possible to have a general definition of music therapy that would be at the same time broad and precise enough, so as to do justice to the various approaches? Such a definition has been provided by Bruscia (1998b), who states, "Music therapy is a systematic process of intervention wherein the therapist helps the client to promote health, using musical experiences and the relationships that develop through them as dynamic forces of change" (p. 20).

As Pellitteri (2009) points out, what lies at the heart of this definition is the idea of emotional processes, although it is not explicitly mentioned by Bruscia. Indeed, emotions are involved in musical experiences as well as in relationships. It is actually impossible to conceive human interaction and artistic expression without the presence of emotions. Besides, any trauma, pain, inner conflict or maladaptive behaviour is obviously associated with a negative emotional experience. This is why Pellitteri (2009) complements Bruscia's definition by saying that "emotions *are* the dynamics of the therapy" (p. 147).

Since music therapy bases its mechanism of action on emotional processes, a chronobiological approach to music therapy requires studying the link between music, emotions and the time of day. However, it would appear that in the Western world, such a study as never been undertaken. Besides, there is no tradition in Western music linking the emotional content of a piece with a specific performance time. Music connoisseurs might object that Western classical music does associate certain pieces with specific times of the day, such as Sibelius's "Night Ride and Sunrise" ("Öinen ratsastus ja auringonnousu"), Falla's "Nights in the Gardens of Spain" ("Noches en los Jardines de España") or Purcell's "Welcome, Welcome, Glorious Morn". However, this association is only a theme present in the composition of the piece, not a recommendation as to when the piece should be played. How should we then proceed?

One way to start our investigation would be to turn our attention to the music culture of northern India. In Indian classical music, each song (or "raga") is supposed to be performed at a specific time. Indeed, according to this tradition, the ability of a song to induce certain emotions varies with the time of day. Hence, playing a song at the right moment is said to maximise its emotional effect.

As it appears, Indian classical music is a very suitable starting point, since it integrates time, music and emotions into a coherent theory, backed by centuries of empirical practice. Obviously, before being able to derive concrete applications from it that could be used in music therapy, it is first necessary to understand the Indian music tradition in its own context.

B. *Indian classical music*

As the reader can probably imagine, the theory of Indian classical music is a vast and complex subject. However, the purpose of this thesis is not to delve into the intricacies of this marvellous art form. Therefore, I will only focus on those aspects and concepts that are needed to explain the logic and motivations behind the time theory.

Before I begin, it is important to keep in mind that in Indian culture, there is always a strong link between art and spirituality. Behind the various art forms, health practices and philosophies that exist in India, one invariably finds the same purpose: to connect with the divine.

Holroyde (1972) shows a profound understanding of this link when she writes: “The mechanics of the mesmerizing music which the vocalist or instrumentalist uses to create suspense and tension in the audience, run parallel to similar techniques in yoga. The end view is the same in both disciplines: the extraction of the mind from self” (p. 47). What she describes with the words “extraction of the mind from self” is the concept of *moksha*, the liberation from the cycle of death and rebirth that leads to the union with God.

Similarly to Christianity, where it is said, “In the beginning was the Word (Logos)” (John 1:1, King James Bible), in Hinduism it is said that in the beginning was *Om*, the primordial sound. In Hinduism, sound (*nada* in Sanskrit) is a fundamental notion, as it not only starts the process of creation, but also holds the material world together (Londhe, 2008). Hinduism distinguishes between a sound that is physically audible (*ahata nada*, struck sound) and a sound that is not mechanically produced and therefore not audible (*anahata nada*, unstruck or unmade sound). The latter can be described as a subtle vibration of the ether or the “sound” of the universe, inaudible but underlying all physical manifestation. Therefore, every audible sound is seen as a materialised and impermanent expression of its unmade equivalent. This idea of inaudible sounds that permeate everything is similar to what Pythagoras called the “music of the spheres” or *musica universalis* (Godwin, 1995).

In the *Sangita Makarandha*, a treatise on Indian classical music from the 11th century AD, *anahata nada* is described as follows: "Sound produced from ether is known as 'unstruck'. In this unstruck sound the Gods delight. The Yogis, the Great Spirits, projecting their minds by an effort of the mind into this unstruck sound, depart, attaining Liberation" (Massey & Massey, 1996, p. 92).

Hindus believe that the *Om* sound is the audible sound that most closely resembles the unstruck sound, and is therefore the most likely to lead to it. This is why *Om* is regarded as the most important and potent sound in the spiritual practice of mantra chanting. Not surprisingly, the Hindu temple can be seen as the origin of all Indian music (Shankar, 2008).

Another fundamental aspect of Indian music and Indian arts in general is their ability to move people and induce specific emotions. The goal is again to transcend the world of form and sound through an experience powerful enough to give us access to the formless. As explained by Raja (2005), “the Indian aesthetic tradition views the sensory experience as a pathway to the emotional, and the emotional as a pathway to the spiritual” (p. 394).

To summarise the Indian view, the “sound” of the universe (i.e. the divine) gives birth to audible sounds which, when skilfully combined, produce beautiful music that has the power to elicit emotions, through which the listener can reconnect with the divine. This movement that goes full circle is just another way of describing enlightenment or *moksha.* Of course, in the Indian aesthetic tradition, music also has a more mundane aspect and can be appreciated as a source of enjoyment only.

When talking about Indian classical music, one has to distinguish between the Hindustani music from the north and the Carnatic music from the south. Both have evolved from the same Hindu tradition, but Hindustani music is characterised by Persian and Islamic influences, and the focus is more on instrumental music. Carnatic music did not have such influences and is therefore more traditional and rigid, with a strong focus on vocal music.

Let us now turn to a description of the most important elements in Indian classical music, starting with the notion of *rasa*.

1. Rasa

At the heart of the Indian aesthetic theory we find the concept of *rasa*. Literally, the word *rasa* means "juice" or "extract", but when applied to music it can be translated as “mood” or “sentiment” (Shankar, 2008). For Holroyde (1972), a *rasa* is a “distilled spiritual mood” (p. 46). This concept was initially developed in the *Natya Shastra* (3rd century AD), an essential Indian treatise on performing arts. Although its main focus is on drama and stagecraft, it actually covers every possible art form, including music, dance and literature (Bharata, 1996). As explained in this treatise, the main objective of Indian performing arts is to express specific *rasas* and elicit a corresponding emotional response in the audience. As a general rule, a work of art can contain several of these emotions, but only one should be dominant.

The *Natya Shastra* describes eight predominant emotions or sentiments: love, pity, anger, disgust, heroism, awe, terror and comedy. Later on, a ninth *rasa* was added (peace, calmness), and the collection became subsequently known as *navarasa* (“nine sentiments”, *nava* meaning “nine” in Sanskrit). This is the list of the nine *rasas* (Raja, 2005):

- *Shringaara*, the romantic sentiment (both physical and mental)
- *Karuna*, the sentiment of pathos (pity, compassion, sadness)
- *Haasya*, the sentiment of mirth (gaiety accompanied with laughter; humorous, comic)
- *Raudra*, the sentiment of wrath or anger
- *Veera*, the sentiment of valour (heroism, bravery, majesty, glory)
- *Bhaya*, the sentiment of fear
- *Bibhatsa*, the sentiment of disgust
- *Adbhut*, the sentiment of surprise, marvel, and amazement
- *Shaanta*, the sentiment of peace

Some musicians and scholars mention a tenth *rasa* (*bhakti*), which is a devotional and spiritual feeling. However, as Shankar (2008) points out, this tenth *rasa* is actually a combination of *shaanta* (peace), *karuna* (sentimentality, sadness) and *adbhut* (marvel).

One thing must be said about the applicability of these nine sentiments to music. The above-mentioned list was defined for performing arts in general. However, certain *rasas* are more easily expressed in some art forms than in others. As Shankar (2008) explains, the sentiments of *bhaya* (fear) and *bibhatsa* (disgust) are not so suitable for music. Therefore, they are almost never expressed in Hindustani music.

One might argue that the *rasa* theory, being the product of a specific culture, is unlikely to be universally valid. However, a recent study conducted in Switzerland (Zentner, Grandjean, & Scherer, 2008) produced a list of nine emotions that bear striking similarity to the nine *rasas*. Since this similarity is too astonishing to be ignored, I will digress for a moment and compare the two lists.

Zentner, Grandjean and Scherer wanted to establish a list of emotional designations that are best suited to describe music-induced emotions. In order to do that, they first compiled a list of emotion terms and tested their frequency across several groups of listeners. These listeners were instructed to describe whether these terms applied to the music or not. After having established a shortlist, they carried out a field study during a music festival, in order to test the validity of the shortlist in so-called "natural settings". The result is a nine-factorial model of music-induced emotions (wonder, transcendence, tenderness, nostalgia, peacefulness, power, joyful activation, tension, sadness). This model is known as the Geneva Emotional Music Scale (GEMS).

The following list shows the GEMS items, their description and the corresponding *rasas*.

- **Wonder**: filled with wonder, allured, dazzled, admiring, moved (*adbhut*)
- **Transcendence**: inspired, feeling of transcendence, feeling of spirituality, overwhelmed (*bhakti*)
- **Tenderness**: in love, sensual, affectionate, tender, mellowed (*shringaara*)
- **Nostalgia**: nostalgic, melancholic, dreamy, sentimental (*karuna*)
- **Peacefulness**: calm, relaxed, serene, soothed, meditative (*shaanta*)
- **Power**: energetic, triumphant, fiery, strong, heroic (*veera*)
- **Joyful activation**: stimulated, joyful, animated, feel like dancing, amused (*haasya*)
- **Tension**: agitated, nervous, tense, impatient, irritated (*raudra*)
- **Sadness**: sad, blue, sorrowful (*karuna*)

The GEMS distinguishes between nostalgia and sadness, whereas the Indian tradition regroups these emotions under the same concept *(karuna*). This is why *karuna* appears twice. As to transcendence, it can be equated with *bhakti* (spiritual feeling), the so-called tenth *rasa*. Having done this, two out of nine *rasas* could still not be placed in the list above, but they happen to be *bhaya* (fear) and *bibhatsa* (disgust), the two *rasas* almost never expressed in Indian classical music. So if we consider that Hindustani music is actually focusing on seven emotions plus *bhakti*, the result is an almost 100% match between the GEMS and the *rasas* expressed in Indian classical music.

That the GEMS model should so closely match a 1800-year-old list coming from another culture is quite surprising to say the least. It seems to indicate that there is something universal behind these music-induced emotions. This hypothesis is corroborated by the findings of Balkwill (1999). She tested the ability of 30 Western listeners to recognise joy, sadness, anger and peace in specific Indian ragas. She found out that the participants were able to recognise at least joy, sadness and anger, without having had any prior knowledge of this type of music. She repeated the experiment with 147 Japanese listeners, and had similar results (Balkwill, Thompson, & Matsunaga, 2004).

Taking into account the studies mentioned above, it would appear that Indian classical music revolves around a set of emotions that could be considered universal. Turning now to musical performance, how are these emotions being conveyed? In India, musicians rely on melodic frameworks known as ragas.

2. Raga

In his autobiography, Shankar (2008) begins his explanation of a raga with a saying in Sanskrit – *Ranjayati iti Ragah* –, which means “that which colours the mind is a raga” (p. 28). This saying summarises very well the essence of a raga, which is to be a vehicle for the expression of emotions, as defined through the nine *rasas*. What we need to do now is understand the structure and design of that vehicle.

Trying to structurally define a raga from a Western perspective is not an easy task, because a raga is neither a scale nor a pre-composed melody, but something in between. Raja (2005) gives a clear, concise and scientific definition: “A raga is a psycho-acoustic hypothesis, which states that melody, created and rendered in accordance with a certain set of rules, has a high probability of eliciting a certain quality of emotional response” (p. 392). We notice again the stress on the ability to express and induce emotions.

One major difference with Western music is that Indian music is not “composed” and written down using a notation system. It is always created anew by the performing artist, who uses his or her sensitivity and skills while following the rules specific to the raga being played. The focus is therefore very much on free improvisation within a melodic framework. Another major difference is that the Indian system is a purely melodic and modal system, whereas the Western system is mainly harmonic. In other words, Indian music does not resort to chords, polyphony or modulation. Instead, it uses microtones and concentrates on the sound quality of every single note. On string instruments, the most common embellishments are obtained through bending and gliding, which gives Indian classical music its characteristic sound.

From this point on, the focus will be solely on Hindustani music, as the time theory that will soon be addressed only concerns Hindustani music. Besides, since the theory of Carnatic music is somewhat different and has not been codified in the same way, it is important to distinguish between the two.

There have been many treatises written about Hindustani classical music, but the treatise that is nowadays regarded as the reference is called *Hindusthani Sangeet Paddhati* (Bhatkhande, 1990). Written by the musicologist Vishnu Narayan Bhatkhande (1860 - 1936), it is an attempt to reconcile theory with centuries of practice. Bhatkhande’s main contribution to Hindustani music is the creation of a coherent classification system to organise the hundreds of existing ragas. Although it has attracted some criticism (see e.g. Roy, 1937), Bhatkhande's theory is nowadays widely recognised. Therefore, if not mentioned otherwise, the following theoretical description will be based on Bhatkhande's classification system.

A raga can be defined by four essential factors:

- A tonic, around which the entire modal structure is built. A drone is always used during performance in order to unambiguously establish the tonic.
- A scale, which must contain between five and nine notes, both in ascending and descending order, without being necessarily the same (usually they are different). These ascending and descending lines are unique for each raga.
- A theme, which is the result of specific melodic figures.
- A dominant (called *vadi*), which is the note played the most frequently and emphasised the most strongly. This note may or may not be the same as the tonic.

Within this framework, the musician is free to improvise by adding ornaments, embellishments, and above all, soul. By breathing life into a raga, the artist makes it the extension of his or her own sensitivity.

Ragas are being organised into groups according to their parent scale or *thaat*. There exist ten of these *thaats*, all bearing the name of a prominent raga (*Bilawal*, *Marwa*, *Bhairav*, *Poorvi*, *Bhairavi*, *Todi*, *Asavari*, *Kalyan*, *Khamaj* and *Kafi*). However, unlike a raga, a *thaat* is only a theoretical construct that serves as the basis for their derivative ragas. Therefore, a *thaat* does not have different ascending and descending lines, nor does it have emotional qualities. As Kaufmann (1965) says, a raga is "alive" whereas a *thaat* is "impersonal" (p. 283).

We have now defined the nature and structure of a raga, as well as its purpose, which is to induce specific emotions. Quite logically, the next step is to find ways to enhance and maximise this emotional effect. In the West, we mainly rely on musical features and interpretation skills. While Indian music does not ignore these aspects either, it has added an extra factor to the equation: the time factor.

3. Time theory

As mentioned earlier, the Hindustani music tradition contains a very elaborate system of specific time associations for each raga. The idea is that people are more or less receptive to the *rasas* depending on the time of day. Therefore, playing a raga at the right time is said to increase its emotional impact (Batish & Batish, 1989; Deva, 1980; Shankar, 2008). In other words, conveying an emotion requires not only an appropriate vehicle (the raga), but also an appropriate time frame.

Currently, this tradition of playing a raga at the correct time is only maintained in the north of India, whereas the Carnatic music from the south has progressively abandoned this practice. This is somewhat paradoxical, as the Carnatic system is known for being more orthodox and traditional than its northern counterpart. According to Shankar (2008), musicians in the south have simply adapted pragmatically to modern concert schedules. Indeed, even in India, Western concert habits have become the norm, and most concerts of

Indian classical music take place in the evening. Had the Carnatic musicians not abandoned the time theory, many ragas would simply not be played anymore. Instead, they chose to save the repertoire by not following the traditional time associations.

How important the time theory really is, depends on the sensitivity and inclinations of the musician. Shankar (2008) for instance believes that the time theory is important, and he therefore tries to follow it as much as possible. According to Kaufmann (1965), the older generation of Hindustani musicians are very strict about playing ragas at their allotted time. However, the trend from the south has started to reach the north, and a growing number of musicians are adding flexibility to the time theory.

As we will now see, time associations are present in the Hindustani music theory on several levels. What these time associations have in common is that they are all derived from structural features of the music. The most basic of these features is the division of the scale.

In Hindustani music, the seven basic notes of the scale are called Sa, Re, Ga, Ma, Pa, Dha, Ni (followed by Sa, one octave higher). The scale is divided into two groups of four notes, each group forming a tetrachord. The lower tetrachord is called *purvanga* ("first limb") and the higher tetrachord is called *uttaranga* ("higher limb"). Depending in which tetrachord the *vadi* (dominant note) is located, a raga will either belong to the group of the *uttar* ragas or the *purva* ragas. The *uttar* ragas are played between midnight and noon, while the *purva* ragas are played between noon and midnight (Jairazbhoy, 1971). Since the momentum of each raga is directed towards the *vadi*, *uttar* ragas have an ascending quality, whereas *purva* ragas have a descending quality (Deva, 1981).

Similarly to the circle of keys and spiral of fifths found in Western music, the ten parent scales are following each other in two consecutive cycles called the circle of *thaats*. Roy (1937) notes that the principle behind these cycles is simply "the tendency of ragas to follow the line of least resistance in the easy transition from scale to scale" (p. 82). Each cycle lasts 12 hours, starting at 7 am. Consequently, every *thaat* is appearing twice in the course of 24 hours, once during daytime and once during the night. Knowing the parent scale of a given raga is therefore not enough to determine when it is being played. One needs to look in which tetrachord the *vadi* is located in order to ultimately determine the performance time.

Furthermore, Bhatkhande divided the 24 hours of the day into eight *praharas* or "beats" of three hours each. All ragas fall into one of these *praharas*. In Bhatkhande's system, the first *prahara* starts at 7 am, whereas some other authors make the cycle start at 6 am (Kaufmann, 1965). This division is therefore not so strict and should rather be regarded as an approximate time frame.

- 7 am - 10 am: 1st beat of the day (daybreak, early morning, morning);
- 10 am - 1 pm: 2nd beat of the day (late morning, noon, early afternoon);
- 1 pm - 4 pm: 3rd beat of the day (afternoon, late afternoon);
- 4 pm - 7 pm: 4th beat of the day (evening twilight, dusk, early evening);
- 7 pm - 10 pm: 1st beat of the night (evening, late evening);
- 10 pm - 1 am: 2nd beat of the night (night, midnight);

- 1 am - 4 am: 3rd beat of the night (late night);
- 4 am - 7 am: 4th beat of the night (early dawn before sunrise).

As we can see, ragas are meant to closely follow the progression of the sun and echo the changes of atmosphere and daylight. During the first half of the day, nature is waking up, expanding, and the sun is rising in the sky. Once the sun has reached the zenith, the process is reversed and nature starts contracting and getting ready for the night. From the point of view of human beings, the first half of the day is characterised by an outward movement (out into the world) and the second half by an inward, introspective movement (the journey home)[1]. Quite interestingly, these movements are being echoed in the ascending quality of the *uttar* ragas and the descending quality of the *purva* ragas.

It is obvious from the preceding description that Bhatkhande was mainly interested in explaining the time associations through structural features of the ragas. However, this tradition had been going on for centuries, without the existence of any "official" theory to support it. It therefore seems legitimate to postulate the existence of a deeper and older explanation, reaching back into the very source of Indian culture.

Anybody attempting such a voyage in time will necessarily encounter the Vedas, the oldest Hindu scriptures. These scriptures were composed during the Vedic Age, an historic period spanning 600 years, starting in the 12th century BC (the early part of the Indian Iron Age). Out of these Vedic texts the Ayurveda was born, one of the oldest medical system still available today. Literally, Ayurveda means "science of life". It is a holistic form of health care taking into account body, mind and soul. Just as everything else in India, it has mythological origins and a spiritual dimension. It therefore values personal and spiritual insights as much as empirical observations (Ninivaggi, 2010).

Ayurvedic medicine is based on the concept of *doshas*, which are basic principles or humours deriving from the combination of the five elements (Air, Fire, Water, Earth and Ether). There exist three *doshas*, called *kapha*, *pitta* and *vata*. Together they form what is called the *tridosha* (*tri* meaning "three" in Sanskrit). *Kapha* can be broadly associated with the ideas of cohesion and structure, *pitta* with fire and transformation, and *vata* with air and movement. It is described in Ayurveda that all living things are made of these three *doshas* combined in different amounts, with one *dosha* usually dominant. The key to health and longevity is a proper balancing of these basic principles, not only within an organism, but also between an organism and its environment (Ninivaggi, 2010).

To use modern medical terminology, the aim of Ayurveda is to support the process of homeostasis. Homeostasis can be defined as the ability of the body or a cell to seek and maintain a condition of equilibrium within its internal environment when dealing with external changes (Segen, 2006). It is a proven fact in modern biology and medicine that without homeostatic regulation, life is not possible. One of the typical phenomena accompanying the aging process is the progressive loss of homeostatic balance, resulting in cell deterioration and a growing instability of the internal environment (Marieb & Hoehn, 2006). Therefore, managing to preserve homeostasis leads to a longer and healthier life.

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[1] This description has both a literal and a figurative dimension, and is valid for one day as well as the course of a lifetime.

One important aspect of homeostasis is the ability of an organism to adjust to the constant changes and pressures coming from the environment. If an organism is not able to adapt to these changes and stay in harmony with its environment, it will first be weakened, and eventually die. This is valid for a cell within an organism, as well as for an organism within its environment. Every organism can adapt and regenerate itself up to a certain point, but if the environmental pressure is too strong and long-lasting, the system will eventually reach its breaking point and collapse. One typical example would be hypothermia, where the body has been exposed to low temperatures for too long.

As described, successful homeostasis is achieved in two ways: by maintaining the balance and regeneration ability of the cells within the organism, while at the same time limiting the amount of stress factors the organism is exposed to. Although it uses another terminology and theoretical framework, this is exactly the goal of Ayurvedic medicine. Typically, an Ayurvedic doctor will first determine which *dosha* is out of balance, and then "pacify" it with targeted drugs or a specific diet that has opposite qualities.

Returning now to the idea of *dosha*, another central concept in Ayurvedic medicine is the *tridosha* cycle. It is said that *kapha*, *pitta* and *vata* alternate over a cycle of 24 hours, starting with *kapha* at 6 am (Ninivaggi, 2010). Every four hours, one of the *doshas* becomes dominant and influences the body/mind/soul in a specific way, making us for example more sensitive to certain emotions. This is where some authors see a possible link between the time associations in Indian classical music and Ayurvedic medicine (Batish & Batish, 1989; Westbrook, 1998). According to these authors, Indian music tradition has developed by taking into account and respecting the *tridosha* cycles, with the idea of only playing music that corresponds to the current state of the cycle. To use again the notion of time quality, if at a certain moment nature, the ambiance, the human body and the human mind are in sympathy around a particular quality, music played at that moment should have the same quality, or else the existing harmony will be disrupted. Seen from that angle, the right music is beneficial for health, while the wrong music is disruptive and even harmful.

This last point is addressed in the already mentioned *Sangita Makarandha.* The treatise warns that, should the performance times not be respected, the listeners will become impoverished and the length of their life will be reduced (Kaufmann, 1965). On the face of it, such a statement might sound bizarre, but one has to put it back into the right context, or translate it correctly into our modern context. What this ancient text seems to be saying is that by challenging homeostasis, one accelerates the aging process and therefore reduces the length of one's life. This statement, once properly understood, can be seen as evidence for the link between the time associations in Indian classical music and Ayurvedic health principles. The possible existence of such a link is further supported by the fact that the eight *praharas* of Bhatkhande's time theory and the *tridosha* cycle of Ayurvedic medicine both start at 6 or 7 am.

Interestingly enough, the idea behind the *tridosha* cycle is the same as the idea behind biological clocks and circadian rhythms. Indeed, Ayurvedic medicine is affirming that there is "something" that makes our physiology and emotions follow a predictable and cyclical pattern over the course of 24 hours, similarly to what we know from chronobiology. One might feel tempted to challenge the scientific validity of this "something", but this would be beside the point. If such a cycle really exists, then it is by definition universal and it should therefore be possible to make it apparent with empirical methods outside the Indian context. In other words, nothing speaks against transposing the Indian time theory into a Western context and testing its validity with Western music and Western listeners. The parallels and similarities I have tried to highlight between Indian and Western ideas (*navarasa* vs. GEMS, *tridosha* cycle vs. circadian rhythms) indicate that such a transposition is clearly possible.

The next part describes a scientific experiment inspired by Hindustani music but based on Western theories and findings in the fields of chronobiology and music psychology. First, I will define some important terms, present relevant theories and propose the rationale behind the experiment. Then, I will describe the actual experiment and present the results. Finally, I will attempt an interpretation of these results.

IV. Music-listening experiment

A. *Theoretical background*

1. Emotion, a multi-facetted concept

When studying music and emotion, every researcher has to take a stance in the debate between cognitivists and emotivists. This debate is about the nature of the emotions linked to music. According to the cognitivists, people who listen to sad or happy music do not really feel those emotions. Whatever affective response arises, it comes from the listener's evaluation of the music. In other words, they believe that music can only represent those emotions, not induce them (Kivy, 1980). In a review of the available research, Scherer and Zentner (Scherer & Zentner, 2001) state, "We are far from being able to provide a clear answer to the question of how music can actually produce emotional states" (p. 382). Researchers who embrace the cognitivist view will therefore focus on perceived emotions and discard the notion of felt emotions.

On the other hand, emotivists argue that emotions are really felt in response to music. To prove their point, many researchers focus on the physiological response to music listening (Krumhansl, 1997; Gomez & Danuser, 2007; Juslin & Västfjäll, 2008). Indeed, if certain physiological changes (e.g. higher heart rate or lower skin conductivity) occur in the listener simultaneously with reported musical emotions, this would prove that the emotions are not just perceived, but are also felt.

One shortcoming of these studies on musically-induced emotions is the difficulty for researchers to distinguish between perceived and felt emotions. Gomez and Danuser (2007) commented at the end of their study: "Despite the wordings in the instructions, one could wonder whether the participants in fact reported the recognized emotional expression rather than how they felt themselves, or whether they mixed these two alternatives" (p. 383). Even by paying ample attention to this issue, it is almost impossible for researchers to guarantee a non-ambiguous and homogenous data collection of felt emotions. This methodological issue needs to be taken seriously, because mistakenly collecting an amalgam of perceived and felt emotions can completely invalidate the study's results.

Another factor making the induction of felt emotions difficult is the importance played by musical taste. Indeed, as shown by Kreutz (2008), the effectiveness of music to induce certain emotions largely depends on the listener's preferences. This means that if a listener likes a particular music style, the emotional response will be much stronger compared to someone who does not like this style.

In short, since felt emotions are more difficult to induce, less systematic and very much depending on musical taste, a study focusing on perceived emotions appears to be much more reliable and easy to carry out. These are the reasons why I designed my music-listening experiment around perceived emotions.

Is it actually possible to give a general definition of "emotion"? The task is difficult, as experts in emotion theory do not agree on a single definition of the term (Izard, 2007). However, Watson (2000) extrapolated from the works of many theorists and attempted to formulate a definition. According to him, emotions are brief and intense states of high-activation that appear as a response to events in our environment.

Furthermore, emotions are always a psychophysiological phenomenon, which means they are accompanied by consistent autonomic changes and physiological arousal.

A concept closely related to "emotion" is the concept of "mood". Although very similar, they are not the same and should therefore be differentiated. A mood could be defined as a relatively long-lasting emotional state. Thayer (1989) explains that moods differ from simple emotions in that they are less specific, less intense, and less likely to be triggered by a particular stimulus or event. In other words, they are influenced mainly by endogenous processes, which makes them perfectly suited for chronobiological studies.

2. Cyclicity of mood

What indications do we have that our mood states are not erratic but cyclical and predictable? A great majority of available studies concentrate on psychopathologies such as depression. We know for example that the mood of subjects with depression appears to closely follow the rhythm of their cortisol secretion, which is not the case in non-depressed subjects (Zerssen, Doerr, Emrich, Lund, & Pirke, 1987). What about the mood of healthy individuals?

Many studies have demonstrated that mood cyclicity is also present in healthy individuals. Clark (1989) and Watson (2000) for example determined that positive mood states display a consistent circadian rhythm, with a low phase in the morning and in the evening, and a peak somewhere in the middle. The moment of this peak varies from person to person, but the general shape of the curve remains the same (Watson, 2000). They also indicated that negative mood states are usually low and constant throughout the day, unless an external event seen as unpleasant or threatening activates the autonomic system and triggers a stress response.

Experimental psychologists commonly refer to positive mood states as Positive Affect (PA) and negative mood states as Negative Affect (NA). Moreover, PA and NA are usually assessed separately and treated as independent dimensions (see e.g. Stone et al., 2006; Vittengl & Holt, 1998; Watson, Clark, & Tellegen, 1988). This might seem counterintuitive, because we tend to think of positive and negative moods as two ends of the same spectrum. In other words, we believe that they cannot be present simultaneously inside the same person. However, studies have repeatedly shown that unless we are dealing with extreme moods, PA and NA actually fluctuate independently of one another.

The reason behind this recurrent observation is that PA and NA belong to different behavioural systems. NA is part of a pain-avoiding system, whose function is to keep us out of trouble. It only gets activated in the presence of a threatening situation, or in anticipation thereof. On the contrary, PA is part of a reward-seeking system, whose role is to make us do things that will be beneficial for our health and survival (as an individual and as a species). PA encourages us for example to obtain the resources we need (Watson, 2000).

From an evolutionary perspective, it would be counter-productive for NA to be high without any good reason, because of the energy consumption involved in maintaining a high level of stress. This is why the default mode of NA is to be low and constant, until something external (real or imagined) activates it. We also see why it is advantageous for PA to follow an endogenous cycle of ups and downs. Since the activities that guarantee our survival always involve cooperation and interaction with other humans (e.g. finding food or sexual partners), coordinating our efforts through circadian rhythms is the best way to be successful in those activities.

3. Mood and perceived emotions in music

Many studies have already confirmed the existence of a strong connection between current mood and emotional evaluation. What stands out in these studies is that a person's mood seems to act as a perceptual filter, creating a bias in our perception and assessment of emotions.

One type of stimulus commonly used by researchers are pictures with facial expressions of various emotions. Surguladze et al. (2004) for example showed that compared to healthy volunteers, people with major depressive disorder are perceptually less sensitive to happy facial expressions. Along the same line, when presented simultaneously with sad and neutral faces, people with major depression tend to pay more attention to sad facial expressions (Gotlib, Krasnoperova, Yue, & Joormann, 2004). Similar results have been obtained when using words with specific prosodic features as stimuli. In a study by Kan, Mimura, Kamijima, and Kawamura (2004), depressed participants tended to perceive neutral words as negative.

The same perceptual bias has been found in musically-expressed emotions. Vuoskoski and Eerola (2011) for example studied the role of mood and personality in the perception of emotions in music. They identified several statistically significant correlations: vigour (positive mood) correlated positively with ratings of happiness in the music, and depression (negative mood) correlated positively with ratings of sadness. Punkanen, Eerola, and Erkkilä (2011) found a similar trend in a study on emotional recognition and depression. They asked a group of depressed participants to emotionally rate the content of musical excerpts. The scores were then compared to the ratings of healthy controls. The results indicated that depressed participants displayed a judgement bias towards negative emotions.

4. Chronotypes

One chronobiological fact that has become widespread is the existence of so-called morning people and evening people, also known as “larks” and “owls”. What distinguishes these two chronotypes is their sleep pattern. Morning people prefer going to bed earlier and waking up earlier, whereas evening people prefer staying up later and waking up later. This results in a phase-shift of their circadian rhythms. Using body temperature as a circadian marker, the phase difference is two hours on average, with morning people two hours ahead of evening people (Kerkhof & Van Dongen, 1996).

However, one common misconception is that everybody is either a morning-type or an evening-type. Actually, only 10% of the population is a true morning-type and 20% a true evening-type (Smolensky & Lamberg, 2001). Most of us are somewhere in the middle, able to be active both in the morning and in the evening. Researchers call these people “hummingbirds”.

What comes to the chronotype's impact on the diurnal mood cycle, chronobiological studies indicate mixed results (Watson, 2000). Nevertheless, two trends are prominent in most studies: morning people reach their peak in positive mood earlier than evening people (usually already before noon), and morning people show overall levels of positive mood that are higher than for evening people. What most studies also confirm is that morningness and eveningness do not affect the basic diurnal pattern described earlier. In other words, independently from our chronotype, we all display a low PA right after waking up and before going to bed, and a PA peak during the course of the day.

Given the relative rarity of true morning and evening people, and since the overall mood pattern is the same for everyone, I decided not to include the chronotype factor in the design of my experiment. Besides, I used a within-subject design, where each participant is tested in every experimental condition, thus serving as his or her own control. The advantage is that it eliminates the distortions linked to individual differences, for example when a participant systematically overrates or underrates certain emotions. In other words, the possible confounding role of extreme chronotypes is reduced by the chosen design.

5. Rationale

When looking at the available research on circadian rhythms, mood fluctuation and the perception of emotions in music, a knowledge gap becomes apparent. Studies have been conducted on the cyclicity of mood, as well as on the perception of emotions in music. Besides, it has been established that our current mood influences our ability to perceive emotions. However, no one has ever linked these elements together and studied the effect of the time of day on perceived emotions in music. If the Hindustani time theory is correct and such a connection does indeed exist, then it could hopefully be made apparent in a specially designed experiment based on chronobiology and Western music.

Since previous mood studies have shown that Positive Affect is usually low in the morning, high in the afternoon, and low again in the evening, I expect to find a perceptual bias of musically-expressed emotions that will correspond to that mood curve. In other words, positive emotions should be perceived as more positive in the afternoon and less so in the morning or in the evening. Inversely, negative emotions should be perceived as more negative in the morning and in the evening, and less so in the afternoon.

B. *Experimental design*

1. Participants

A total of 36 people participated in the experiment. All the participants were recruited among students or researchers from the University of Jyväskylä. Their age ranged from 19 to 39, with an average of 25 years (SD = 4.2). A majority of them were female (75%). As to their nationality, 15 participants were Finns and the remaining 21 were foreign students. Most of the non-Finns were Europeans, with a few exceptions (two Chinese participants and one West-African participant). None of the participants were native English speakers. All of the participants were familiar with Western film music, and 86% said that they pay quite a lot attention to music when watching a film. The level of self-assessed musicality was rather high, with an average of 4 on a scale of 1–5 (SD = 1).

2. Session choice

The experiment was conducted over a two-week period, from January 30th to February 15th, 2012. During that time, six morning and five afternoon sessions were organised. Each participant had to choose one morning session (9 am) and one afternoon session (4 pm), but not necessarily on the same day or in that order. In other words, participants' first session might be a morning or an afternoon session, and they might do the sessions on the same day or on different days. This was decided for practical reasons. First of all, the capacity of the computer class was limited to 12 people. Moreover, giving several options to choose from made it easier for participants to find slots that would suit their own schedule.

In the end, 16 participants started with a morning session and 20 with an afternoon session. Furthermore, 13 participants did both parts on the same day, and 23 participants did them on different days.

3. Music stimuli

Very often in the study of music and emotion, the music clips are arbitrarily chosen, meaning that there is no guarantee they will accurately convey the intended emotion. Another common problem is that the chosen clips are often well-known pieces of Western classical music. Being easily recognisable by the average participant, episodic memory linked to that specific piece could interfere with the emotional perception or effect the researcher is trying to investigate.

To avoid these problems, the Department of Music of the University of Jyväskylä has created a dataset of music clips specifically designed for the study of music and emotion. The 110 clips constituting this dataset have been carefully selected through a pilot study followed by a large validation study (Eerola & Vuoskoski, 2011). They are all unfamiliar excerpts from recent film soundtracks, lasting around 15 seconds each. The style is Western classical music, which is the dominant style in film scores.

During the validation study, each clip had been rated by 116 non-musicians using both the discrete and dimensional model of emotion. The target emotions were anger, fear, happiness, sadness and tenderness. This means that for each clip in the dataset, I knew what the average rating on each target emotion was. For my experiment, I chose three highly representative examples and two moderate examples of each target emotion. Highly representative examples had an average rating of 6.5 and moderate examples an average rating of 5 for the specific emotion they were meant to express (on a scale of 1 – 9).

Since I was using a within-subject design where each participant had to come twice, I did not want to re-use the same playlist, which might have led to implicit or explicit memory effects. I therefore created two different but comparable playlists of 25 clips each, referred to from now on as playlist A and playlist B (for the detail of the playlists, see Appendix). In order to counterbalance the presentation of the stimuli, half of the participants listened to playlist A in the morning and B in the afternoon, while the other half listened to playlist B in the morning and A in the afternoon. Furthermore, the presentation order of the clips inside the playlists was randomised for each participant.

As to the order of the sessions, it was not completely counterbalanced, since 16 participants started with a morning session and 20 participants with an afternoon session. However, this is not a crucial issue here, since the experiment did not contain the kind of task where participants get better through practice. Besides, the participants would anyway listen to a different playlist each time, and the playlists were always preceded by two example clips (not belonging to any playlist), so that the participants could get familiar with the type of music and the rating scales.

4. Apparatus

The experiment was conducted in a computer class using iMac computers. Each computer was equipped with an MBox 2 soundcard and high-quality headphones (AKG K141). The interface for the music listening part was designed with PsychoPy, version 1.72. This open-source application is written in the Python language and it is compatible across operating systems. It allows for the presentation of stimuli and the collection of rating results (Peirce, 2007).

5. Initial questionnaire

Each session consisted of a questionnaire followed by the actual music-listening part. The idea behind the questionnaire was to collect general information and to assess the current mood of each participant prior to rating the music clips. For the mood evaluation, the Positive Affect Negative Affect Schedule (PANAS) was used. The PANAS is composed of 20 mood adjectives, 10 for Positive Affect (active, alert, attentive, determined, enthusiastic, excited, inspired, interested, proud, strong) and 10 for Negative Affect (afraid, scared, nervous, jittery, irritable, hostile, guilty, ashamed, upset, distressed). Each item is rated on a scale of 1–5. In order to extend the scope of the PANAS, three extra items were added to the evaluation (tired, calm and sad). On average, it took the participants five minutes to complete the initial questionnaire.

As noted by Thompson (2007), the original PANAS poses some problems when used in an international context with non-native English speakers. Many of the mood adjectives have shown to be unclear or ambiguous in the context of "international English". Thompson therefore conducted an extensive cross-cultural validation of the original 20 items and proposed a short form of the PANAS with only 10 items. Since I wanted to keep the original PANAS, I circumvented the language problem by adding some semantic explanations to the most unfamiliar and ambiguous items.

Because the sleep-wake cycle has an influence on the phase of various circadian rhythms, I asked the participants how many hours they slept on the night before the current session. I also asked them at what time they woke up, because the proximity of sleep has been shown to predict the current point of people's mood cycle. People who just woke up are likely to have a much lower positive mood state compared to people who woke up eight hours ago and should be by now very close to their peak in positive mood (Watson, 2000).

6. Music rating

After the initial questionnaire, the participants had to listen to 25 film music excerpts with an average length of 15 seconds each. Their task was to rate the emotional content of each clip using five rating scales, one for each target emotion (anger, fear, happiness, sadness and tenderness). The rating scales ranged from 1 to 9.

The participants were explicitly asked to rate the perceived emotions and not the felt emotions. The instructions contained a short explanation of the difference between the two.

The interface was designed in such a way that participants could only proceed to the next clip once all the five ratings were done. They were also given the possibility to replay the clip if needed. A screenshot of the rating interface can be seen in Figure 7. Most participants completed the music-listening part in 25 minutes or less.

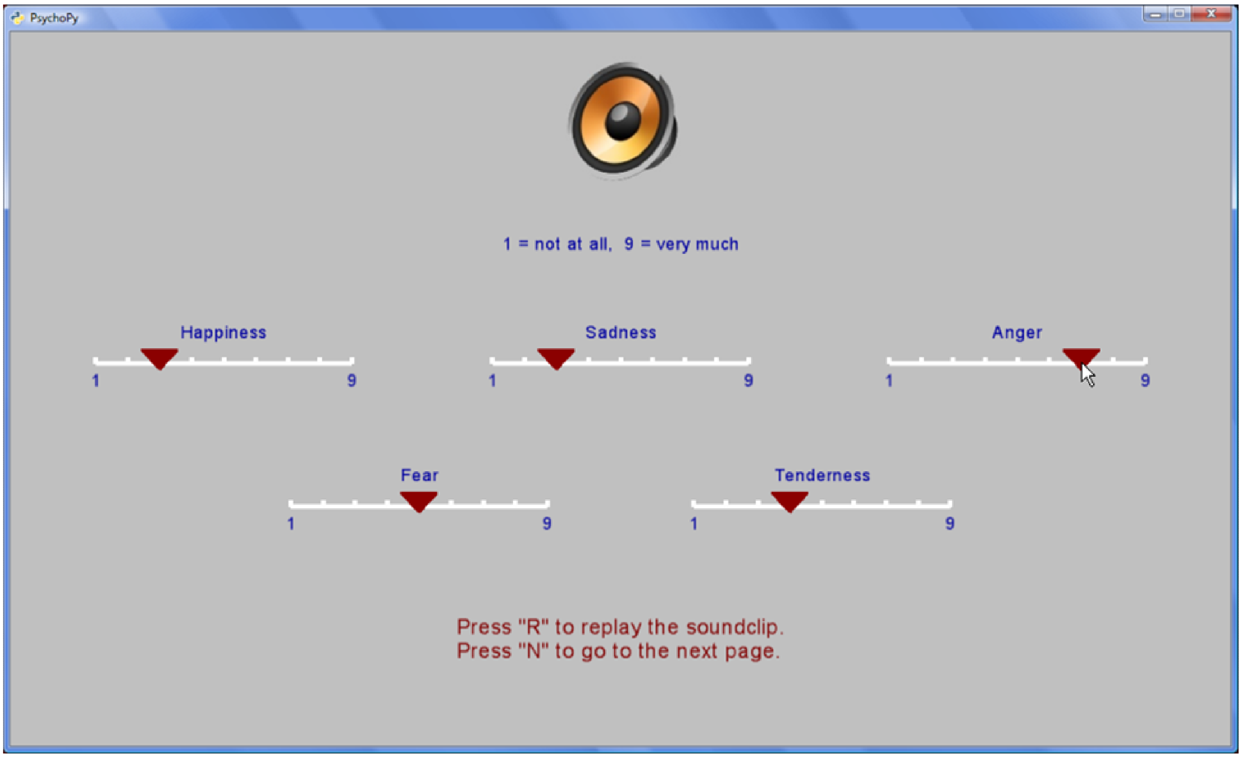

Figure 7. User interface of the music listening experiment

C. *Results*

1. Mood evaluation

Let us first take a closer look at participants' sleep-wake cycle. On average, participants slept 6.7 hours before the 9 am session (SD = 1.3) and 6.9 hours before the 4 pm session (SD = 0.97). A paired samples *t*-test revealed that this difference was not statistically significant ($p = .4$). Furthermore, 80% of the participants slept at least 6 hours before the morning session, and 95% did so before the afternoon session. The sample was therefore very homogenous in terms of sleep length, and that length was long enough to assume that none of the participants were experiencing disrupted circadian patterns because of sleep deprivation.

On average, participants awoke 1.5 hours before the 9 am session (SD = 0.7 hour) and 7.9 hours before the 4 pm session (SD = 1.3 hours). The range was quite small in the morning (3 hours), but it became very large in the afternoon (7 hours) because of two extreme values (one participant woke up at 6:30 am and another at 12:15 pm).

In order to determine the existence of possible outliers, the Mahalanobis Distances were calculated for each participant, using two sets of variables (NA_am - NA_pm and PA_am - PA_pm). No one exceeded the critical value for df = 2 and $p < .001$ (critical value: 13.82).

Looking specifically at the mood scores of the two participants with extreme values in wake-up time, both had very similar PANAS scores, and these scores were close to the group's average (within one standard deviation of both PA and NA). It therefore appeared that their difference in wake-up time did not affect their mood scores.

Taking into consideration the two findings above, the whole dataset (n=36) was used to analyse the mood scores.

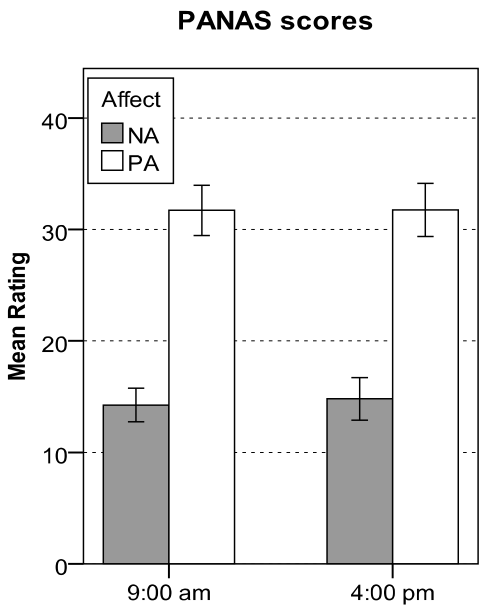

Figure 8. Mean PANAS scores for all the participants (n = 36), error bars: 95% CI

When averaging the mood scores for all the participants, NA and PA were almost identical between the morning and afternoon ratings (see Figure 8). Without looking further into the data, it would appear that there was no mood fluctuation throughout the day, which stands in contradiction to the findings of mood researchers. Diurnal mood cyclicity has been observed many times in the past. It would therefore be surprising if the current participants did not present any difference at all in their mood states.

In order to investigate the matter further, correlation measurements were made between the PANAS scores and other participant data collected through the initial questionnaire. Because not all the factors followed a near-normal distribution, a non-parametric measure of correlation (Spearman's ρ) was used to analyse the variables.

Table 3. Morning correlations between the PANAS scores and other indicators

		Tired_am	Sad_am	Calm_am	NA_am	PA_am	Hours slept
Tired_am	Spearman's rho	1					
	Sig. (2-tailed)						
Sad_am	Spearman's rho	.263	1				
	Sig. (2-tailed)	.121					
Calm_am	Spearman's rho	.066	-.171	1			
	Sig. (2-tailed)	.704	.311				
NA_am	Spearman's rho	.070	.374*	-.430*	1		
	Sig. (2-tailed)	.684	.029	.029			
PA_am	Spearman's rho	.144	-.109	-.052	.109	1	
	Sig. (2-tailed)	.401	.529	.765	.528		
Hours slept	Spearman's rho	.126	.004	.129	-.038	.056	1
	Sig. (2-tailed)	.464	.985	.453	.824	.745	

* p < .05

Only two significant correlations existed in the morning: a positive correlation between Sad and NA ($\rho = .374$, $p < .05$), and a negative correlation between Calm and NA ($\rho = -.430$, $p < .05$). These correlations were to be expected, since sadness and calmness are a negative and a positive affect respectively. Therefore, it is logical for them to be related to NA, PA or both. Because Sad and Calm are not part of the original PANAS, they were measured independently. It is also worth mentioning that there was no significant correlation with Tired, which indicates that participants' mood scores were not related to their current level of tiredness (in the morning).

Table 4. Afternoon correlations between the PANAS scores and other indicators

		Tired_pm	Sad_pm	Calm_pm	NA_pm	PA_pm	Hours slept
Tired_pm	Spearman's rho	1					
	Sig. (2-tailed)						
Sad_pm	Spearman's rho	.607**	1				
	Sig. (2-tailed)	.000					
Calm_pm	Spearman's rho	-.003	-.076	1			
	Sig. (2-tailed)	.987	.659	.			
NA_pm	Spearman's rho	.448**	.676**	-.351*	1		
	Sig. (2-tailed)	.006	.000	.036			
PA_pm	Spearman's rho	-.507**	-.547**	-.033	-.610**	1	
	Sig. (2-tailed)	.002	.001	.848	.000		
Hours slept	Spearman's rho	-.089	.047	.288	-.038	-.378*	1
	Sig. (2-tailed)	.606	.783	.089	.826	.023	

* p < .05, ** p < .01

Looking now at the afternoon data, there was a mild correlation between the hours slept the night before and the afternoon PA scores ($\rho = -.378$, $p <.05$). Interestingly enough, this correlation was negative, which means that PA decreased with each extra hour of sleep. This was the only statistically significant correlation involving the amount of sleep in the whole dataset.

Unlike in the morning, the level of tiredness correlated positively with the NA score ($\rho = .448$, $p < .01$), which means that Negative Affect increased when tiredness increased. Furthermore, the level of tiredness correlated negatively with the PA score ($\rho = -.507$, $p < .01$), which means that Positive Affect decreased when tiredness increased. Lastly, tiredness also correlated positively with sadness ($\rho = .607$, $p < .001$). These correlations confirm what common sense tells us about mood and tiredness.

Similar to the morning results, there were again statistically significant correlations between the PANAS scores and the ratings for Sad and Calm. Calm correlated negatively with NA ($\rho = -.351$, $p < .05$), and Sad correlated positively with NA ($\rho = .676$, $p < .01$) and negatively with PA ($\rho = -.547$, $p < .01$). However, as previously mentioned, such correlations are to be expected, since sadness and calmness are affects closely related to what the PANAS is measuring.

Whereas the NA and PA scores appeared completely unrelated in the morning ratings, they correlated moderately in the afternoon ($\rho = -.610$, $p < .001$). This correlation was negative, which means that Negative Affect decreased as Positive Affect increased. Such a correlation was rather unexpected, because one of the robust properties the PANAS is to consist of largely uncorrelated scales (Watson et al., 1988). Subsequent studies have shown that the correlation between NA and PA usually ranges from -.05 to -.35 (Watson & Clark, 1999). A correlation of -.610 was therefore largely beyond the expected values and hinted at the presence of a confounding factor. It made sense to assume that this confounding factor was Tiredness. This assumption was supported by the sudden presence of correlations between NA, PA and Tiredness in the afternoon (see Table 4), while no such correlations existed in the morning (see Table 3).

Because of these unexpected correlations, the mood scores were analysed again, after having created two tiredness groups using a median-split ("Tired" and "Not Tired").

Since this study followed a within-subject design, performing a median-split would have required considering both the morning and afternoon tiredness scores of each participant. In case those scores should have differed greatly from each other, that person could not have been placed in any tiredness category. However, as we just saw, tiredness did not relate anyhow to participants' morning mood. It was therefore possible to give a tiredness label based only on participants' afternoon tiredness scores. This made the selection process simpler and solved the problem of having to drop participants with diverging tiredness scores.

Consequently, participants scoring 1 or 2 ($n = 13$) were placed in the category "Not Tired", whereas participants scoring 4 or 5 ($n = 15$) were labelled "Tired". As to participants scoring 3 ($n = 8$), they were dropped from the dataset.

PANAS scores

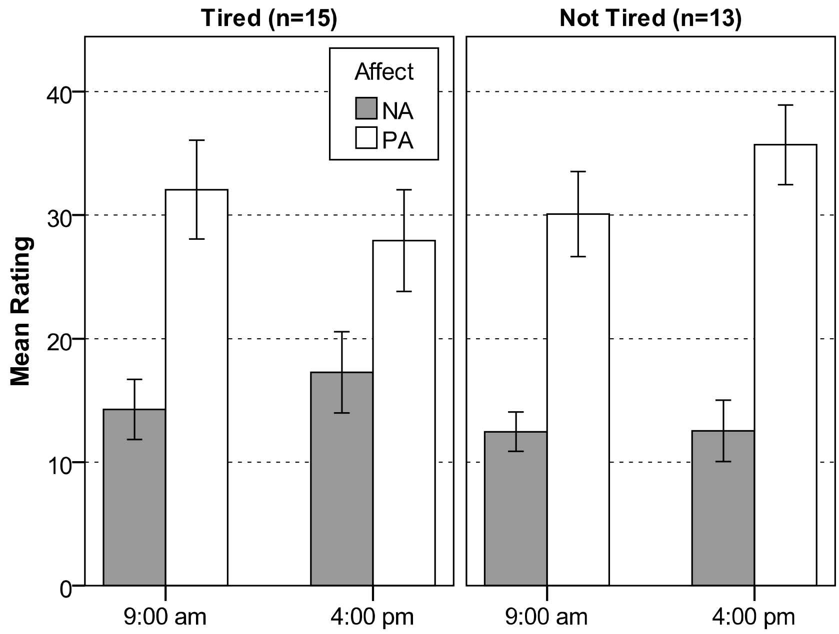

Figure 9. Mean PANAS scores of Tired vs. Not Tired participants (error bars: 95% CI)

The first striking observation was that the mood scores of tired versus non tired participants displayed diverging trends (see Figure 9). Both groups started out with morning scores that were very similar. However in the afternoon, tired participants experienced an increase in NA and a decrease in PA, whereas not tired participants saw their PA increase and no change in their NA. The decrease in PA displayed by tired participants was statistically significant (t (14) = -3.08, p < .01), and so was their increase in NA (t (14) = 2.19, p < .05). As to the non tired participants, their increase in PA was also statistically significant (t (12) = 4.07, p < .01).

These diverging mood scores between the two tiredness groups explain why Figure 7 revealed no difference in the PANAS scores: when pooling together all the participants, these opposite trends cancelled each other out, resulting in no apparent mood difference between the morning and the afternoon. Moreover, it is noteworthy that only participants in the Not Tired group displayed mood trends in line with the theory. Indeed, the PANAS scores usually obtained by mood researchers show no significant change in NA, and an increase in PA between the morning and the afternoon.

Moving now to a between-subject comparison of the afternoon scores only (with tired as a grouping variable), an unrelated *t*-test for PA and a Mann-Whitney *U* test for NA were performed. The latter non-parametric test was used because, unlike PA, NA did not follow a normal distribution.

The unrelated *t*-test showed that the PA difference for the tired (M = 27.93 SD = 7.4) and the non tired participants (M = 35.69, SD = 5.33) was statistically significant, t (26) = -3.13, p < .01, two-tailed. As to the Mann-Whitney *U* test applied to NA, it revealed that the average rank of tired participants (17.97) was significantly higher than the average rank of non tired participants (10.5), with U = 45.50, z = -2.42, p < .05.

To summarise, the differences in NA and PA scores of tired versus non tired participants were both statistically significant in the afternoon. The NA scores of non tired participants were significantly lower and their PA scores significantly higher than the scores of tired participants. These results demonstrate that in the afternoon, non tired participants were in a more positive mood than tired participants.

2. Music rating

Similarly to the mood score analysis, it was first necessary to check for the existence of possible outliers in the emotion ratings. The Mahalanobis Distances were calculated for each participant, using two sets of variables (anger_am, fear_am, happiness_am, sadness_am and tenderness_am for the first set; anger_pm, fear_pm, happiness_pm, sadness_pm and tenderness_pm for the second set). No participant exceeded the critical value for $df = 5$ and $p < .001$ (critical value: 20.52). Therefore, the whole dataset ($n=36$) was used to analyse the music ratings.

All the emotion ratings from the music clips followed a normal distribution. However, since some mood indicators did not, a non-parametric measure of correlation (Spearman's ρ) was used to analyse the variables.

After calculating the correlation coefficients between the emotion ratings and the various mood indicators, several statistically significant relationships became apparent:

- Happiness_am correlated positively with PA_am ($\rho = .390$, $p <.05$) and Calm_am ($\rho = .318$), but the latter correlation only approached significance ($p = .059$).
- Sadness_pm correlated positively with NA_pm ($\rho = .378$, $p <.05$).
- Fear_pm correlated positively with NA_pm ($\rho = .316$, $p = .06$) and negatively with PA_pm ($\rho = -.289$, $p = .087$), however these correlations only approached significance.

Interestingly enough, the statistically significant correlations involving Happiness_am and Sadness_pm are corroborated by Vuoskoski and Eerola (2011). In their study, they used clips from the same dataset and tested the same five target emotions, although time of day was not controlled for. Instead of the PANAS, they used the POMS (Profile of Mood States) to assess participants' initial mood. Their results showed a positive correlation between Vigour and the ratings on the Happiness scale ($r = .32$, $p < .01$), as well as a positive correlation between Anger and the ratings on the Sadness scale ($r = .33$, $p < .01$). Given the adjectives that make up the two dimensions of the PANAS, POMS Vigour can be compared to PA and POMS Anger to NA (Watson & Clark, 1999). Although all these correlations are not very strong, they support the idea that people's current mood influences their perception of emotions expressed by music.

Cronbach's alpha was used to calculate the inter-rater reliability for each emotion scale across the two experimental conditions (morning and afternoon). The reliability was very high for the anger, fear and happiness scales ($\alpha > .99$, both in the morning and the afternoon), and only slightly lower for the sadness and tenderness scales ($\alpha > .98$ in the morning and $\alpha > .97$ in the afternoon for both scales). Generally speaking, these results maintain that the emotion ratings were highly consistent. Consequently, the data could safely be pooled together and analysed.

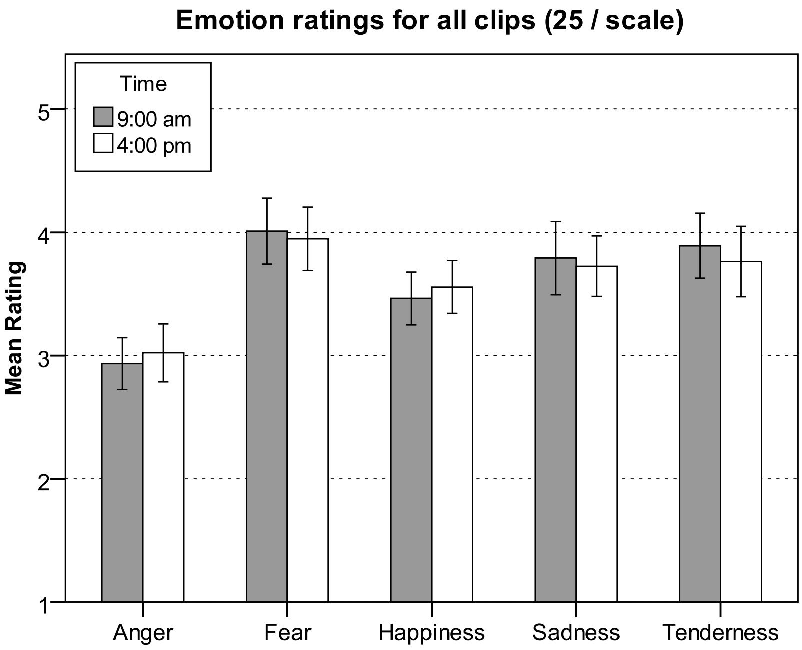

Figure 10. Mean ratings of all the participants (n=36) on the five emotion scales for all the clips (25 clips per scale), error bars: 95% CI

The mean rating results for each emotion scale can be seen in Figure 10. The average level of anger, fear, happiness, sadness and tenderness perceived by the participants in all the 25 clips combined did not differ significantly between the morning and the afternoon. So it would appear that participants' sensitivity to emotions expressed by music did not change over time.

However, one has to keep in mind that the clips were chosen to express specific target emotions (5 clips per target emotion, 25 clips in total). Therefore, when participants gave ratings on a specific emotion scale, they were not only rating the clips expressing that specific emotion, but also the clips expressing the four other emotions. By looking only at the mean rating produced by a specific scale, the rating difference for a specific block of clips across time might have been masked by the presence of 20 other clips expressing other emotions. Consequently, it was decided to look at the ratings in more detail in order to determine whether time had an effect or not.

Instead of looking only at the overall ratings of the 25 clips, this time the scales were analysed individually and the clips regrouped in blocks of five, each block expressing a specific target emotion. The idea was to find out whether the clips expressing the same target emotion were rated differently between the morning and the afternoon. Proceeding in this way made it possible to discover how clips were rated on the scale measuring that specific emotion (e.g. how the happy clips were rated on the happiness scale), but also how the clips were rated on the other four scales (e.g. how the happy clips were rated on the anger, fear, sadness and tenderness scales).

Figure 11 displays – for each scale – the ratings given to the clips expressing the same target emotion.

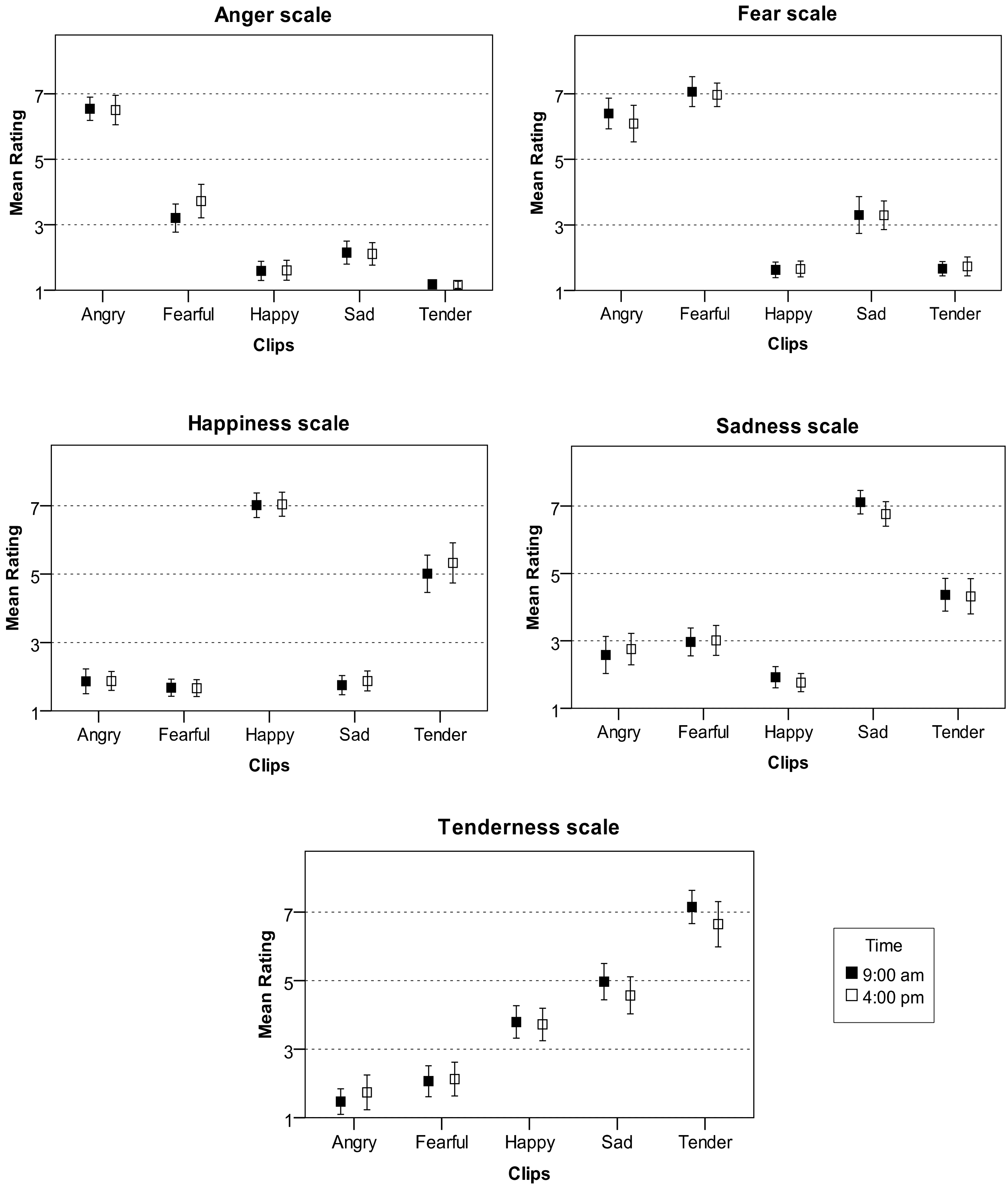

Figure 11. Mean ratings on the five rating scales of the clips regrouped by target emotion. Participants: n=36. Error bars: 95% CI.

Repeated measure ANOVAs were carried out for each of the five rating scales separately. The results of the analysis are shown in Table 5 and 6.

Table 5. Results of the repeated measure ANOVAs comparing scale-use and target clips

		Clips				
Scale	Factor	angry	fearful	happy	sad	tender
Anger	Time		p < .05			
Fear	Time					
Happiness	Time					
Sadness	Time				p = .05	
Tenderness	Time				p < .05	p < .05

Sample size: n=36. Only significant (or nearly significant) main effects are reported.

Table 6. ANOVA results: effect sizes of the significant results from Table 5

	F	Effect size (η^2)	Observed power
Anger: fearful clips	4.54*	.11	.55
Sadness: sad clips	$4.09^{\dagger}$	.01	.50
Tenderness: tender clips	4.81*	.12	.57
Tenderness: sad clips	4.67*	.12	.56

† p = .05, * p < .05

The repeated measure ANOVAs revealed that the time factor had a main effect on the way fearful clips were perceived in terms of anger ($p < .05$, $\eta^2 = 0.11$). The fearful clips were rated significantly higher on anger in the afternoon (M = 3.72, SD = 0.25) compared to the morning (M = 3.20, SD = 0.21). However, this result does not really tell us anything about a change in anger perception, because the angry clips did not indicate any difference in anger rating between the morning and the afternoon. Therefore, the only thing that can be concluded is that fear expressed by music was perceived as more angry in the afternoon.

The time factor also had a main effect on the way sad and tender clips were perceived in terms of tenderness ($p < .05$, $\eta^2 = 0.12$ for both). Both sad and tender clips were rated significantly higher on tenderness in the morning (M = 4.97, SD = 0.26 and M = 7.1, SD = 0.24) compared to the afternoon (M = 4.57, SD = 0.27 and M = 6.65, SD = 0.33). These results appear to indicate a general reduction of participants' sensitivity to tenderness in the afternoon. Indeed, when creating the clip dataset used in the present experiment, Eerola and Vuoskoski (2011) noticed that sad and tender clips were easily confused when rated on tenderness. Both types of clips tended to have high tenderness ratings (tender clips rated the highest, followed by sad clips). Similar findings can be observed in Figure 10. Therefore, the lower afternoon ratings in tenderness for both tender and sad clips can be seen as the expression of the same phenomenon.

The same trend could be observed for the sadness rating of the sad clips, with higher rating of sadness in the morning (M = 7.12, SD = 0.17) compared to the afternoon (M = 6.77, SD = 0.18). However, the rating difference only approached statistical significance ($p = .05$, $\eta^2 = .01$). To be very accurate, p was equal to 0.051, so at the very limit of the conventional significance level. It is also worth mentioning that the effect size of this decrease in sadness rating was much smaller compared to the changes observed on the tenderness and anger scales.

To see whether tiredness was playing a role in the emotion ratings, correlation measurements were made between the tiredness scores and the ratings of the clips regrouped by target emotion (separately for each rating scale).

The only statistically significant correlations were found with the Fear scale, where Tired_pm correlated positively with angry_pm ($\rho = .33$, $p < .05$) and fearful_pm ($\rho = .49$, $p < .05$). These correlations indicate that the more tired the participants were, the more fearful was their perception of angry and fearful music. Again, these two correlations can be merged into one and regarded as relating to musically-expressed fear. Indeed, just like for the ratings of sad and tender clips mentioned earlier, Eerola and Vuoskoski (2011) discovered that fearful and angry clips tended to receive very similar ratings on the fear scale. Therefore, the ratings of fearful and angry clips can be linked to the perception of fear in general.

Similarly to the mood scores, tiredness only seemed to play a role in the afternoon. Indeed, no correlations were found with Tired_am, on any of the rating scales. This systematic absence of morning correlations involving tiredness – both in the mood evaluation and the music rating – will be discussed in the next part.

3. Summary

The results of the music-listening experiment revealed that participants were more sensitive to musically-expressed sadness and tenderness at 9 am compared to 4 pm. Furthermore, the level of afternoon tiredness was linked to the perception of fear: tired participants perceived fear in music as more fearful than participants who were not tired. The correlation involving tiredness was not part of the original hypotheses, but it became apparent during the course of the data analysis.

The non-significant effects are also worth mentioning, since only two emotions out of five displayed significant rating differences. The other three emotions (anger, fear and happiness) had almost identical perception levels between the morning and the afternoon, when rated on their corresponding scale (fearful clips on the fear scale etc.).

D. *Discussion*

1. Results in the light of Indian classical music

Since the starting point of the experiment was the association of Hindustani ragas with a certain time of day, it would be interesting to look at the results in the light of Indian musical practices. Are the findings involving the perception of sadness and tenderness somehow corroborated by the performance schedule of Hindustani ragas?

The following is a list of prominent morning ragas (in chronological order) and a description of their typical emotional content (Kaufmann, 1965):

- *Bhairava* (early morning): sad and serious, with an awe-inspiring feeling of grandeur
- *Bhairavi* (early morning): peaceful, serious, slightly sad and loving
- *Todi* (morning): gentle peacefulness, idyllic adoration
- *Bilaval* (late morning): affectionate, tender joyfulness

We notice that morning ragas predominantly express the feelings of love, devotion, sadness and tenderness. Sadness is especially dominant in the early morning, and as the hours go by, it is progressively replaced by a more joyful content. As we can see, the results obtained from the music-listening experiment are actually supported by the performance habits in Hindustani music.

Generally speaking, Yardi and Chew (2004) have shown that ragas performed between late night and morning are what they call “bottom heavy”, whereas ragas performed between late morning and early evening are “top heavy”. Bottom heavy ragas are characterised by solemn and grave emotions, whereas top heavy ragas evoke lighter and happier emotions. This evolution in emotional content is clearly visible in the four ragas listed above.

For Debu Chaudhuri, the eminent sitarist and former head of the Faculty of Music at the University of Delhi, such an evolution is not surprising. Indeed, he believes that the morning ragas echo the state of our nervous system: after waking up, we are rested and still stress-free, thus more sensitive to gentle and melancholic music (Schrott, 2001).

2. Self-evaluation of tiredness

One peculiarity of the presented results is the systematic absence of statistically significant correlations involving morning tiredness. In contrast, several such correlations could be found in the afternoon, where tiredness correlated negatively with Positive Affect, and positively with sadness, Negative Affect and perception of musically-expressed fear. Why would these perfectly sensible correlations be present only in the afternoon?

One possible explanation is that the participants were not able to accurately assess their actual level of tiredness in the morning. The reason for such a lack of reliability could be the proximity of sleep. Watson (2000) has shown that PA is very low immediately after waking up and rises sharply for approximately two hours. After these two hours, it continues rising but at a much slower pace, until it reaches its peak, on average six hours later. On a more general level, we know from chronobiological studies that everybody experiences a slight morning depression after waking up, which dissipates after ca. two hours (Smolensky & Lamberg, 2001). In my experiment, the participants’ average wake-up time was 1.5 hours before the morning session (SD = 0.7 hour). In other words, most of them were still in that two-hour time frame where they had presumably not yet reached their normal daytime mood.

Quite obviously, assuming a lack of reliability in participants' self-ratings is not a fully satisfactory explanation. If we assume instead that the self-ratings are reliable, then an alternative explanation would be that participants were in fact rating two different things. Indeed, the concept of tiredness includes more than one aspect. It can refer to physical fatigue, but also to mental exhaustion. In both cases, the feeling of tiredness typically occurs after some form of physical or mental activity. However, there is still another closely related aspect which is sleepiness. Sleepiness refers to the desire to sleep or to the efforts to resist sleep. Since tiredness and sleepiness often co-occur, the terms are usually used interchangeably. However, they refer to two separate phenomena that can also happen independently from one another. After physical exercise for example, one will usually feel tired but not necessarily sleepy. Inversely, people suffering from narcolepsy will experience sudden sleepiness not accompanied by any fatigue.

If the second hypothesis is correct, then participants were predominantly rating sleepiness in the morning and tiredness in the afternoon. This could have easily occurred, as the initial questionnaire did not specify the exact meaning of "tired", leaving the door open to multiple interpretations. Besides, as I already mentioned, the morning sessions were characterised by a sleep proximity of less than two hours for most participants. Under these circumstances, it is certainly possible that only their afternoon ratings were assessing true physical and mental tiredness, whereas their morning ratings were concentrated on the feeling of not being fully awake.

Whatever the reason behind the absence of correlation in the morning, the correlations found in the afternoon are being corroborated by previous studies investigating the link between tiredness, mood and optimism. The general idea is that people who are not tired are in a better mood, and therefore see negative things in a more positive light. Conversely, tiredness is typically accompanied by a lower mood and a negative perceptual bias. Thayer (1987) for example has established that people perceive their personal problems as being much worse when their level of energetic arousal was low, in other words when they were tired. Similarly, Kanning (2010) has demonstrated that when people's level of energetic arousal increased, so did their positive mood. This is in line with the (afternoon) results of the present experiment: non tired participants were in a more positive mood than tired participants, and the perceived intensity of musically-expressed fear increased together with the level of tiredness.

3. Implications and applications

Although this thesis is written as part of a Music Therapy Master's Programme, the results of the music-listening experiment have implications that actually go beyond the field of music therapy.

To begin with, they add to the body of knowledge available in chronobiology, where the focus has traditionally been on physiological processes and not so much on psychological and emotional issues. One exception are the studies on mood cyclicity that serve as a basis for this present experiment. Furthermore, the current results demonstrate that carefully selected music can be used as a tool to study mood fluctuations.

For researchers studying music and emotion, the present findings highlight the importance of taking into account the time of day when planning an experiment. Until now, this factor has usually been ignored.

Participants are typically being tested at various times, and the results are then pooled together, as if they had been obtained at the same time. Should the current findings be confirmed by subsequent studies, then controlling for the time factor might prove to be crucial in order to maintain consistency and avoid distortions in the results.

Ethnomusicologists and Indian musicians also benefit from this study, as it gives them empirical evidence to explain and support the traditional time-raga associations in Hindustani music. If people have indeed a heightened sensitivity to tenderness and sadness in the morning, then it makes complete sense for the morning ragas to emphasize these emotions.

Finally, the current findings open a new direction for music therapy. The initial question was whether music therapy could be improved by considering the time factor, the same way biomedicine is benefiting from the findings in chronopharmacology. In my opinion, there would be two ways of integrating the time factor in the daily practice of music therapy.

The first scenario is the situation where the client's and the therapist's timetables are both flexible, meaning that the sessions could be scheduled any time. The idea here would be to make the time match the therapeutic goals and the client's needs. Finding out what the best matches are could be the focus of future studies. One could for example hypothesise that dealing with a heavy emotional burden might be easier in the early afternoon, when people seem to be in a better mood and less sensitive to negative emotions (both in general and when expressed by music).

In reality, the requirements of a busy modern life would make the previous scenario quite unlikely. Professional music therapists who see many clients every day have to place the appointments consecutively in their schedule, which makes it impossible for each client to get the most suitable time (therapeutically speaking). Besides, since emotional issues are very common among the population seeking professional help, it means that therapists should only receive clients in the early afternoon, which is of course not realistic.

As a result, a more likely scenario is the situation where therapists do not have control over the time of a session. In that case, they could still use the knowledge derived from studies on mood cyclicity and music perception to adjust the content and interpretation of a given session. If the therapist knows that s/he and the client will both be more sensitive to tenderness and sadness in the morning, then the meaning given to the verbal and musical exchange could be modulated accordingly. A therapist working for example inside the psychodynamic framework could look at the various transferences and countertransferences in a different light depending on the time of day. In the case of Guided Imagery and Music, the therapist could use that information when selecting the music programme the client will be listening to.

4. Limitations and future research

It is obvious that the present study is only the first step into a new and promising direction. Since its scope and the means employed were limited, the current findings would need to be replicated and expanded by more extensive experiments.

Two evident improvements would be to sample more than two moments of the day and to measure the same participants over several days. In the current experiment, only 9 am and 4 pm were chosen, and each participant was tested only once in the morning and once in the afternoon. Adding more points in time would allow us to cover the whole day and give us a better picture of what the daily cycles really are. Ideally, measurements should be taken at regular intervals, starting in the morning immediately after rising and ending just before participants are going to bed. Moreover, the number of participants could be increased and the experiment repeated daily for at least one week, so that each person would be assessed many times at each chosen point of the day. By averaging a participant's repeated ratings, one would obtain more reliable results for each given time.

The only drawback of this type of extended experiment is the need to use a much larger song database in order to avoid too frequent repetitions of the same clips. Ideally, the clips should not be repeated at all, as was the case in the present experiment. However, what was easy to implement with only two points in time tested once would suddenly become extremely complex, maybe even impossible to realise in a satisfactory manner. Under those circumstances, it might be useful to devise a new way of measuring sensitivity to emotions expressed by music.

Another direction definitely worth exploring would be to test not only circadian but also circannual rhythms. Indeed, cyclical mood variations manifest not only on the level of a day, but also on the level of a year. Harmatz et al. (2000) for example found strong seasonal variations in depression, hostility, anger, irritability and anxiety among a large sample (n = 322) drawn from a healthy population. Since what affects our mood is very likely to affect our perception of emotions in music, we can expect to find a seasonal effect for both. It would therefore be interesting to repeat the same music-listening experiment several times during the year and then compare the results. Indian classical music could again serve as a starting point, since the Indian time theory also associates certain ragas with each season of the year.

This last aspect was beyond the scope of the present study, but it should not be neglected, as it could have useful applications in music therapy. We might for example find out that certain therapy processes are easier or have different outcomes depending on when they are started during the year. This type of reasoning is obviously needed for issues like Seasonal Affective Disorder (SAD), where depressive symptoms are always appearing during one specific season (usually in the winter). In this case, it would be wise to start the therapy process before and not during the season in question. On a more general level, circannual findings could probably be applied in music therapy to help with a wide range of emotional issues, not just issues involving extreme seasonality like SAD.

Conclusion

The purpose of this work was to raise the awareness for the existence of cycles and the benefits that can be derived from following them. The main idea was that since various levels and aspects of reality tend to naturally oscillate in synchrony, any addition of man-made elements should follow the same rhythm, lest the existing harmony be disrupted. In that sense, focusing on music was very appropriate, as it is an art form based on the ideas of harmony, synchrony and rhythm.

In the course of this study, we saw how a shift in the Western world view changed our conception of time, how the idea of time quality and cyclicity was partially reintroduced through chronobiology, and how circadian rhythmicity could be used to optimise our health and the efficacy of medical treatments. All these facts prepared the ground for the idea that also music therapy could benefit from such an approach. In the absence of any suitable Western musical tradition, we turned towards Hindustani music and its elaborate time theory. This led to the creation of a music-listening experiment aimed at uncovering the existence of diurnal cycles in our perception of musically-expressed emotions.

The current study did not investigate how the impact of music therapy changes with the time of day. Instead, it focused on the perception of emotions expressed by music, which is only a preliminary step. However, it is a required step needed to establish whether the consideration of time in music therapy is an alley worth exploring. The current findings strongly suggest that this is indeed the case.

As announced in the very first pages, another of my intentions was to demonstrate that it is possible to reconcile empirical sciences and the humanities. Hence, I intentionally drew on a vast array of knowledge while highlighting relevant connections and similarities. Proceeding in this manner allowed me to offer a wider perspective, so as to avoid reducing the subject at hand to biological processes only. Indeed, the reason why there are so many academic disciplines is because one discipline alone cannot possibly provide all the answers. I therefore believe that the most fruitful attitude for a researcher is to be open-minded and to have an interdisciplinary approach where ideas are properly understood, creatively combined, and eventually tested.

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Illustration sources

Figure 1:

Painting of the Goddess Saraswati by Raja Ravi Varma, 1896
Oil on canvas
Maharaja Fateh Singh Museum, Vadodara, Gujarat
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Figure 2:

Relief with Kairós personification, 2nd Century a.D.
Museo di Antichità di Torino, Italy
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Figure 3:

Peter Apian, *Cosmographia*, Antwerp, 1524
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Figure 4:

Astronomical clock, Cathedral of Münster (Germany)
Detail
Original photographe: Ziko van Dijk, 2007
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Figure 5:

Flower clock
Drawing by Ursula Schleicher-Benz. From: Lindauer Bilderbogen (Series 1, No.5). Published by Thorbecke Verlag, Lindau/Reutlingen, 1948.
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Figure 6:

Created by Olivier Brabant, with information taken from Palmer (2002) and Smolensky & Lamberg (2001)

Figure 7:

Screenshot of the original rating interface, designed by Olivier Brabant in PsychoPy

Appendix

Detail of the playlists used in the music-listening experiment

Playlist A:

No.	Target emotion	Rating	Album name	Track	Min:Sec
1	ANGER_HIGH	6.13	The Fifth Element	19	00:00-00:20
2	ANGER_HIGH	6.38	Hellraiser	5	00:00-00:15
3	ANGER_HIGH	6.47	The Fifth Element	13	00:17-00:31
4	ANGER_MODERATE	4.64	Batman Returns	2	00:18-00:33
5	ANGER_MODERATE	4.18	Man of Galilee CD1	2	03:45-04:02
6	FEAR_HIGH	6.34	JFK	8	00:08-00:25
7	FEAR_HIGH	6.79	The Alien Trilogy	5	00:26-00:41
8	FEAR_HIGH	6.17	Grizzly Man	16	01:05-01:32
9	FEAR_MODERATE	4.58	Running Scared	6	02:53-03:07
10	FEAR_MODERATE	5.28	Cape Fear	2	01:25-01:40
11	HAPPY_HIGH	6.63	The Rainmaker	3	02:55-03:13
12	HAPPY_HIGH	6.89	The Untouchables	6	01:50-02:05
13	HAPPY_HIGH	6.36	Shine	5	02:00-02:16
14	HAPPY_MODERATE	5.60	Dances with Wolves	10	00:28-00:46
15	HAPPY_MODERATE	4.87	Shine	15	01:00-01:19
16	SAD_HIGH	6.78	The English Patient	18	00:07-00:32
17	SAD_HIGH	5.73	Man of Galilee CD1	8	01:20-01:37
18	SAD_HIGH	6.17	Blanc	18	00:00-00:16
19	SAD_MODERATE	5.28	Oliver Twist	2	00:00-00:29
20	SAD_MODERATE	4.89	Dracula	5	00:11-00:27
21	TENDER_HIGH	6.66	Shine	10	01:28-01:48
22	TENDER_HIGH	6.06	Pride & Prejudice	1	00:10-00:26
23	TENDER_HIGH	5.39	Oliver Twist	8	01:15-01:32
24	TENDER_MODERATE	4.62	Blanc	12	00:51-01:06
25	TENDER_MODERATE	4.85	Big Fish	8	00:12-00:34

Playlist B:

No.	Target emotion	Rating	Album name	Track	Min:Sec
1	ANGER_HIGH	6.39	Lethal weapon 3	8	04:15-04:29
2	ANGER_HIGH	6.31	The Alien Trilogy	9	00:03-00:18
3	ANGER_HIGH	5.42	Cape Fear	1	02:15-02:30
4	ANGER_MODERATE	4.13	The Untouchables	8	01:38-01:53
5	ANGER_MODERATE	3.27	Crouching Tiger, Hidden Dragon	8	01:12-01:25
6	FEAR_HIGH	6.52	Hannibal	1	00:40-00:54
7	FEAR_HIGH	6.19	The Fifth Element	9	00:00-00:18
8	FEAR_HIGH	6.12	JFK	8	01:26-01:40
9	FEAR_MODERATE	5.74	Shallow Grave	4	01:04-01:19
10	FEAR_MODERATE	4.98	Shakespeare In Love	11	00:21-00:36
11	HAPPY_HIGH	6.81	Batman	18	00:55-01:15
12	HAPPY_HIGH	6.60	Batman	4	02:31-02:51
13	HAPPY_HIGH	6.28	Oliver Twist	1	00:17-00:34
14	HAPPY_MODERATE	5.11	Man of Galilee CD1	2	00:19-00:42
15	HAPPY_MODERATE	4.79	Gladiator	17	00:14-00:27
16	SAD_HIGH	6.38	Juha	16	00:00-00:15
17	SAD_HIGH	6.12	Big Fish	15	00:55-01:11
18	SAD_HIGH	5.66	Blanc	10	00:13-00:31
19	SAD_MODERATE	5.15	Running Scared	15	02:06-02:27
20	SAD_MODERATE	4.85	Crouching Tiger, Hidden Dragon	13	01:52-02:10
21	TENDER_HIGH	6.57	Lethal weapon 3	10	01:59-02:17
22	TENDER_HIGH	5.48	Pride & Prejudice	12	00:01-00:15
23	TENDER_HIGH	5.34	Grizzly Man	1	00:00-00:27
24	TENDER_MODERATE	4.70	Nostradamus	2	01:09-01:28
25	TENDER_MODERATE	4.43	Dracula	4	00:55-01:09

The values in the column “Rating” are the average ratings of the target emotion (scale: 1 – 9) obtained by Eerola and Vuoskoski (2011) in the second part of their pilot study. These values were used as reference for selecting the clips.

The complete datasets (360 and 110 clips respectively), along with the aforementioned paper, can be freely accessed here:

www.jyu.fi/hum/laitokset/musiikki/en/research/coe/materials/emotion/soundtracks