UNIVERSIDADE ESTADUAL PAULISTA "JÚLIO DE MESQUITA FILHO"
INSTITUTO DE ARTES
PROGRAMA DE PÓS-GRADUAÇÃO EM MÚSICA

MYRIAM HADASSAH

WRITING FOR PEDAL HARP: COGNITIVE ASPECTS

SÃO PAULO - SP

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Dissertação apresentada ao Programa de Pós-Graduação em Música do Instituto de Artes da Universidade Estadual Paulista "Júlio de Mesquita Filho" (IA/UNESP) como requisito parcial para obtenção do título de Mestre em Música.

Área de concentração: Música: processos, práticas e teorizações em diálogos. Linha de pesquisa: Música, Epistemologia, Cultura.

Especialização: Cognição Musical.

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Ficha catalográfica preparada pelo Serviço de Biblioteca e Documentação do Instituto de Artes da Unesp

H125w Hadassah, Myriam, 1981-
Writing for pedal harp : cognitive aspects / Myriam Hadassah. - São Paulo, 2020.
126 f. : il. color.

Orientador: Prof. Dr. Marcos José Cruz Mesquita
Dissertação (Mestrado em Música) – Universidade Estadual Paulista "Júlio de Mesquita Filho", Instituto de Artes

1. Música para harpa. 2. Música - Instrução e estudo. 3. Neurociência cognitiva. 4. Pierné, Gabriel,1863-1937. 5. Ravel, Maurice, 1875-1937. 6. Villa-Lobos, Heitor, 1887-1959. I. Mesquita, Marcos José Cruz. II. Universidade Estadual Paulista, Instituto de Artes. III. Título.

CDD 787.9

(Laura Mariane de Andrade - CRB 8/8666)

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DEDICATÓRIA

Dedico esta pesquisa as minhas sobrinhas Hellen Regina e Amélie Hadassah.

AGRADECIMENTOS

Minha gratidão a Deus pela música.

A minha família, em especial a minha mãe Ester Sforzin, por me apoiar e esforçando-se junto a mim, para cumprimento de todas as demandas desta pesquisa.

Aos meus professores e funcionários da Escola Municipal de Música do Teatro Municipal de São Paulo, principalmente do período de 1993 à 2005, onde obtive a base da minha formação musical em Harpa de Pedal e Teoria da Música.

A Fundação VITAE (Principado de Lichtenstein) que por meio de sua bolsa de estudos no ano de 2004 adquiri, na época, material técnico sobre a harpa de pedal.

A todos que direta ou indiretamente me auxiliaram nesta pesquisa.

Agradeço a dedicação dos professores, funcionários e equipe de gestão do Instituto de Artes da UNESP em suas orientações prestadas para a elaboração deste trabalho.

Minha gratidão ao meu prezado e benquisto orientador Prof. PhD Marcos José Cruz Mesquita, pelo incentivo, instrução e colaboração para o desenvolvimento e ampliação de meus conhecimentos musicais, ideias e pesquisa.

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“The perception of the unknown is the most fascinating of the experiences.”

Albert Einstein

ABSTRACT

This work aims to develop research on the neurocognitive process of writing for pedal harp. Due to some peculiarities of the instrument, there is a little repertoire for harp, prevailing a large number of keyboard transcriptions and not idiomatic works for the instrument. Given this assumption, we sought to know the human neurocognitive process applied to perception for musical harp composition. In order to contribute to data collecting about the process of perception, the research was made with bibliographic survey and literature of the researched areas. It approaches the cognitive and musical neuroscience, to understand the musical representations of the musical notation with reference to orchestral treatises and pedal harp literature. The research found similar forms and patterns in three works considered masterpieces for the instrument: Pierné (1901), Ravel (1905) and Villa-Lobos (1953). Similar musical designs were found in the musical development of the three works, hand structures in predetermined forms and an implicit perception (cognitive aspects) for the use of harp pedals (explicit aspects - orchestration treatises and pedal harp literature).

Keywords 1. Musical Cognition. 2. Pedal Harp. 3. Gabriel Pierné. 4. Maurice Ravel. 5. Heitor Villa-Lobos.

RESUMO

O presente trabalho busca desenvolver pesquisa sobre o processo neurocognitivo da escrita musical para harpa de pedal. Devido a algumas peculiaridades do instrumento, constatou-se pouco repertório para harpa, contando com grande número de transcrições de peças de teclado e obras não idiomáticas para o instrumento. Diante deste pressuposto, procurou-se conhecer o processo neurocognitivo humano aplicado a percepção para composição musical na harpa. No intuito de contribuir para a coleta de dados sobre o processo de percepção da composição para harpa, a pesquisa foi feita com levantamento bibliográfico e literatura das áreas pesquisadas. Aborda a neurociência cognitiva e musical, para se compreender as representações musicais da notação musical implícitas, com referência a tratados orquestrais e literatura da harpa de pedal. A pesquisa encontrou evidências de formas e padrões similares em três peças consideradas obras primas para o instrumento: Pierné (1901), Ravel (1905) e Villa-Lobos (1953). Foram encontrados desenhos musicais similares no desenvolvimento artístico musical das três obras, estruturas das mãos similares em formas pré-determinadas, e uma percepção implícita (aspectos cognitivos) para o uso dos pedais da harpa (aspectos explícitos - tratados de orquestração e literatura para harpa de pedal).

Palavras-chaves: 1. Cognição Musical. 2. Harpa de Pedal. 3. Gabriel Pierné. 4. Maurice Ravel. 5. Heitor Villa-Lobos.

FIGURES

TABLE

SUMMARY

1 INTRODUCTION

This research has its basis in the studies of cognitive neuroscience of music and investigates the cognitive interweavement of visual and motor aspects of pedal harp technique and score reading.

The harp is an ancient instrument and its sound possibilities have always been limited to the technical features in each historic period. Since especially the second half of the nineteenth century, orchestration treatises present the main characteristics of pedal harp to students and composers.

The pedal harp acquired resources from the eighteenth century on to accompany the development, for instance, of tempered tuning and of harmonic chromaticism. The pedal mechanism of the harp was also adapted until reaching a technical consensus for performance. However, the amount of musical works for the instrument does not correspond to its development and technical possibilities. Koechlin (1954) states that:

> The harp is a very agile instrument (see, for example, Hasselmans' *Les Feux Follets*) only restricted to good writing: but most composers remain shy, because they are very ignorant of the subject.[1] (KOECHLIN, 1954, p.119)

Such severe statement demonstrates a recurrent situation about doubts regarding the technical possibilities of the instrument, which resulted in a shortage of orchestral works with harp, or, much worse, idiomatically mistaken works. For example, it is said that the harp cadenza from Tchaikovsky's Nutcracker Ballet (figure 1) was idiomatically rewritten by a harpist and by convention it is still played as in figure 2. Although it had Tchaikovsky's approval at the time, the composer did not change its original score (ADLER, 2002).

[1] All translations from author.

Figure 1. Original cadenza for harp from The Nutcracker (1892) “Waltz of the Flowers”, measures16-18. (TCHAIKOVSKY, 1892, apud ADLER, 2002, p.93)

Figure 2. Cadenza, as usually performed, from The Nutcracker, “Waltz of the Flowers”, measures 16-17. (TCHAIKOVSKY, 1892, apud ADLER, 2002, p.93)

We can observe some other examples in works written with idiomatic inadequacies, and sometimes passages had to be rewritten or, if not, omitted during the performance. Usually, such problems are present more frequently in symphonic works.

In the example below (figure 3), Berlioz (1830 apud KONHAUSER & STORCK, 1994), even being recognized as an orchestration expert, writes a mistaken passage in the *Symphonie Fantastique*. Konhauser and Storck (1994) state that: “It is advisable to share this passage between two harps as it is almost impossible to play at the original tempo.” (KONHAUSER & STORCK, 1994, p.13). Therefore, the harpist usually plays only the upper staff, alternating his hands in the sequence suggested by the tuplets.

Figure 3. Impossible musical passage from *Symphonie Fantastique*, 2nd movement, Valse, measure 31. (BERLIOZ, 1830, apud KONHAUSER & STORCK, 1994, p.13)

In this other passage (figure 4), Wagner (2001) writes notes in the last measure that do not exist in harp notation, i.e., double-sharp notes. Konhauser and Storck (1994) rewrote the entire passage solving this problem by changing enharmonically the key, resulting in a richer sound (figure 5): the pedal harp, as we will see later, has a better resonance in flat keys because its natural tuning is flat.

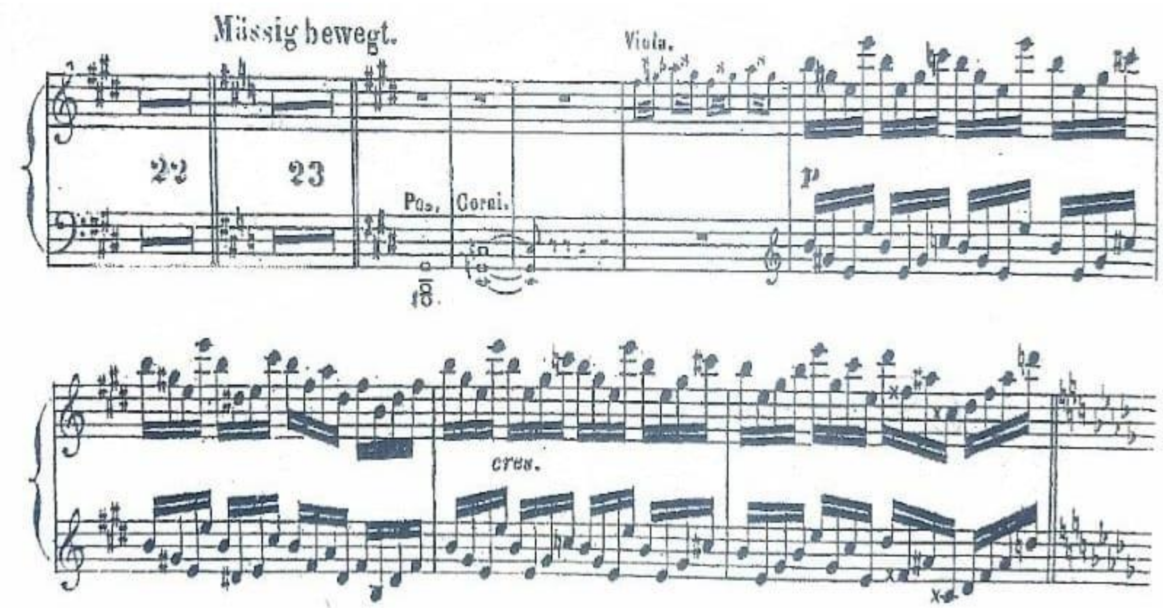


Figure 4. Musical excerpt written with notes that do not exist on the pedal harp, e.g., bent sharps. Harp part from Die Walküre, 3rd act, letter J (WAGNER, 2001, p.2).

Figure 5. Harp part rewritten enharmonically from Die Walküre, 3rd act, letter J (WAGNER, 1856, apud KONHAUSER & STORCK, 1994, p.100).

In the following passage (figure 6a), Stravinsky (1942, apud KONHAUSER & STORCK, 1994) writes chords in a very large range for the left hand. Konhauser & Storck (1994) solved this idiomatic inadequacy, adapting the passage with enharmonic notes, i.e., the notes Cb and Bb rewritten respectively as natural B and A# (figure 6b).

a. b.

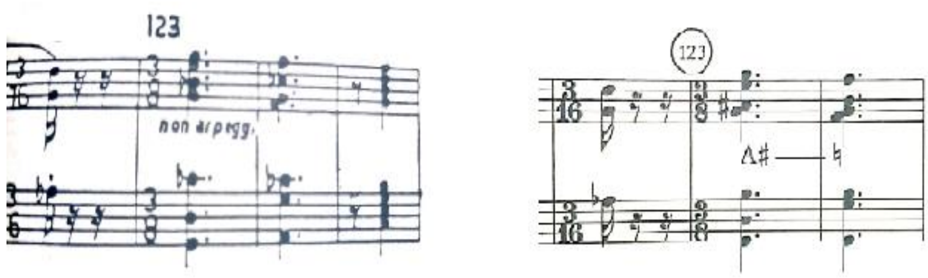


Figure 6. *Symphony in Three Movements*, 2nd movement. a. original harp part, and b. reviewed harp part. (STRAVINSKY, 1942, apud KONHAUSER & STORCK, 1994, p.49)

Bartok (1946) requests the use of pedals in a non-idiomatic way, i.e., he mixes sharps and flats, something that make more difficult the activation of pedals (figure 7).

In such cases, the harmonic configuration is not clearly written, and there is a conflict between hand and feet actions. Konhauser & Storck (1994) solves the problem by enharmonizing specific chord notes (figure 8).

Figure 7. Harp part 1 and 2 from Concerto for Orchestra, problematic chords circled in red (BARTOK, 1946, p.70, 71).

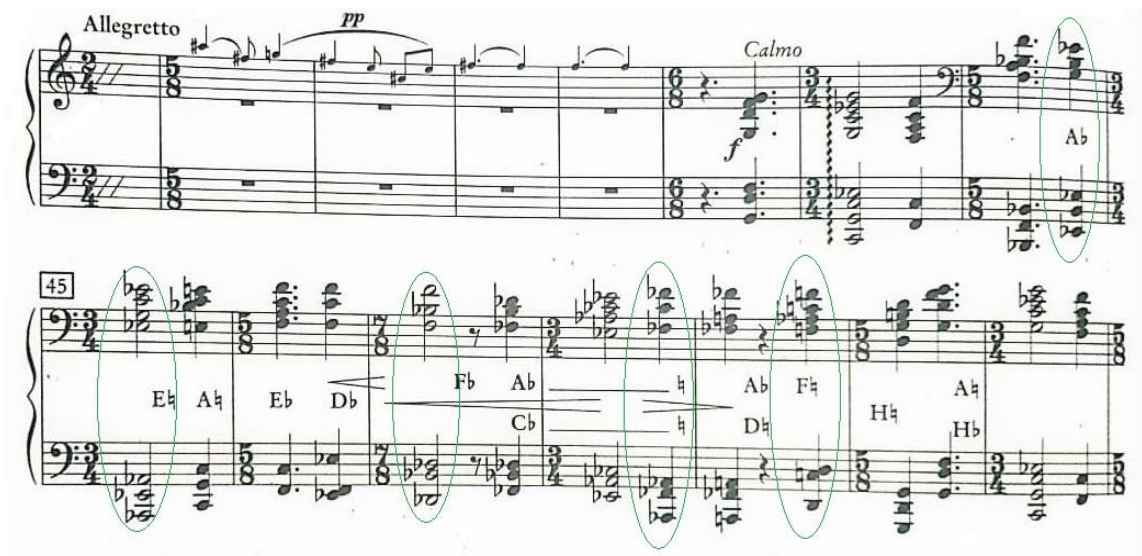


Figure 8. Harps 1 and 2 from *Concerto for Orchestra*, problematic chords rewritten enharmonically circled in green (BARTOK, 1943 apud KONHAUSER & STORCK, 1994, p.10).

Such examples show us common mistakes about the pedal harp notation in important musical works: idiomatic inadequacies of the harp fingerings that are many times related to problems of idiomatic inadequacies in the use of pedals. Also Magnani (1989) considers that musical works for solo harp are limited, he states that:

> The expressive limitations of the harp made its repertoire always very scarce: Mozart's Concerto for harp and flute and Boieldieu's Concerto are the highlights of orchestral literature. [...] But almost all of the recital literature is represented by transcriptions of pieces [...] (MAGNANI, 1989, p.25)

However, despite the constant idiomatic inadequacy in the musical notation of the harp, we can infer that the modern technique of the pedal harp is objectively and clearly described in orchestration treatises (ADLER, 2002; ALEXANDER, 2008; BERLIOZ, 1855; KOECHLIN, 1954; MACDONALD, 2004; MILLER, 2015; PISTON, 1969). Some authors advise, however, to contact a harpist for a complementary explanation (ADLER, 2002; KOECHLIN, 1954). We can conclude that there are limitations on the part of composers that generate idiomatic inadequacies about pedal harp writing.

Today, with the progress of cognitive neuroscience, we can review some perception difficulties that are not yet referred in the existing material, aiming an improvement of harp writing. In such perspective, this research seeks to answer following question: what human cognitive aspects could be involved to improve the perception of pedal harp writing? The answer to such question can elucidate the implicit cognitive processes in the visual perception of the pedal harp notation, so that the composer does not necessarily have to find a harpist to solve gaps in observational perception. Such strategy can contribute to the cognitive accessibility of the composition, and to the expansion and development of the pedal harp repertoire.

The research was developed mainly bibliographically. Therefore, we will observe first the most discussed idiomatic topics in the literature and orchestral repertoire for the pedal harp. The description of harp features includes strings characteristics, sound possibilities, hands and fingers positions and movements, pedals uses, and musical notation.

Then, we used cognitive neuroscience studies to discover a possible perceptual sensory gap applicable to the research problem. It will be observed that the human cognitive processing system is complex, but extremely organized. We limited the discussion to how information is processed by the sensory system and is decoded and understood in brain. We will observe the path of the stimuli from the reception in the sensory systems (visual, auditory, and senses-integrated) until the organizational perception in the cortex, i.e., how the stimuli are organized as mental percept for understanding. Then, we will approach the Gestalt Theory (theory of form), the one that perhaps better explains the moment of mental percept, i.e., the perceptual processing of sensory inputs before the "higher" semantic recognition of an object or form.

The Gestalt Theory, first based on psychophysical aspects of visual perception, was developed by Wertheimer (1912; 1923), Koffka (1936), and Köhler (1947) It also contributes as an analytical tool for psychophysical and cognitive musical perception (BREGMAN, 1994; DEUSTCH, 1982; MESQUITA, 2016; SHEPARD, 1999), and, in other musical cognitive approaches, for studies in musical expectation and emotion (MEYER, 1956). The German word Gestalt has a conceptual meaning associated with configuration or form. Gestalt Theory suggests that human perception interprets the whole, the form. Each observed part is a forming element of a whole, and perception is a global response to mental, corporal, or behavioral stimuli. Gestalt perception would be the mental organization of such stimuli. (BOCK; FURTADO; TEIXEIRA, 2002).

After finding the cognitive moment of a mental percept formation (Gestalt), we also seek to investigate the processing of psychophysical stimuli in the cortex and to consider how the observation of musical notation (visual stimuli) would accurately correspond to musical production (auditory recognition and motor actions) in the brain. We did not investigate directly the sensorimotor cognitive aspects of harp playing, but discuss such topic with the help of orchestral treatises and a selected instrumental literature.

Following the previous premises, we can try to give an answer to the main question of the research: if a musical work is written with the help of sound concepts and correspondent motor behaviors that are established through convention in musical notation, its mental percept should be a set of visual idiomatic "drawings" (Gestalts) that are intrinsically bound to such sound concepts and motor behaviors. Therefore, such drawings (Gestalts) can be graphically found in standard works for the instrument.

Three pieces of the harp repertoire were selected in order to support the analysis and data collection: *Concertstück* for harp, Op.39, by Gabriel Pierné (1901), *Introduction and Allegro* by Maurice Ravel (1905) and *Concerto para harpa* by Heitor Villa-Lobos (1953). In the early twentieth century, the pedal harp reached an apex of its musical development and the three mentioned works represent exemplary such apex.

The analysis of selected musical excerpts started from the premise that visual perception is considered implicitly equivalent to resulting auditory perception and motor behavior (the last in the case of a performer), i.e., sound perception and motor behavior are symbolically represented in visual patterns of the musical score. The musical excerpts were selected in order to present the most characteristic technical possibilities of pedal harp, as exposed in instrumentation/orchestration treatises. Then, the selected excerpts were analyzed with the help of structural musical analysis and their structural characteristics were compared with the principles of Gestalt Theory. Finally, we propose a classification that synthesizes such data.

The text is articulated in five chapters, the first being this introduction. In the second chapter, we describe the idiomatic and technical aspects of the pedal harp. In the third chapter, we describe aspects of the visual and auditory perceptual sensory systems; we observe and compare the interaction of the visual and auditory perceptual sensory system, which induce a mental percept in cortex. We will approach such perceptual moment using principles of the Gestalt Theory. In the fourth chapter we analyze the perceptual organization suggested by Gestalt Theory, considering musical notation (visual stimuli) in accurate equivalence to auditory cognitive perception, in following musical works: *Concertstück* for harp, Op.39, by Gabriel Piernè (1901), *Introduction and Allegro*, by Maurice Ravel (1905) and *Concerto para harpa*, by Heitor Villa-Lobos (1953). Chapter five is dedicated to final considerations.

2 TECHNICAL ASPECTS OF PEDAL HARP

2.1 The Pedal Harp

The harp is an ancient instrument. We find its first and oldest historical register in the beginning of the Holy Bible, in the Genesis book (circa 1446 B.C.): "Jubal: he was the father of all such as handle the harp (…)" (HOLY BIBLE, 1611, p. 4). Due to its existence in many cultures with different names, the term *harp* was instituted as a kind of historical consensus. The first mention of the term is given by bishop Venantius Fortunatus, around 600 AD (BLOM, 1954). Therefore, the term “harp” was instituted for all instruments with similar physical characteristics in biblical translation and in all Western cultures.

The contemporary pedal harp has a mechanism that is operated by pedals. In the pedals, there are springs that drive cables through the column of the harp, triggering the mechanism in the neck by turning discs with forks, this way tightening or releasing the strings in half tone. There are two movements for each pedal: flat bass (first movement for natural) and natural bass (second movement for sharp). Hence the concert harp is also called the double-action pedal harp. This mechanism is used in order to take in account the Western tonal system, i.e., the tempered system.

The tonal system prevailed when the pedal harp was patented in 1810 by Sébastien Erard in France (ZINGEL,1992). The harp had already been excluded from the great musical production because it was not completely adapted to the tonal system, especially to the use of chromaticism. Sebastién Erard (1810) brought the harp back to the social scene of the world of music, when the harp was limited to court music in Europe. Beginning discretely in 1810, the new pedal harp reached its apex in late Romanticism and early French Impressionism, enriching with its timbre the expression of musical compositions.

The contemporary pedal harp has the same structure since Erard (1810) and today has three sizes:

- Petite Harp (40 strings to 44 strings): played in small environments;

• Semi-grand harp (46 strings): used in orchestra and chamber ensembles;

• Concert grand harp (47 strings): harp commonly used by all harpists in orchestras, concert halls, music schools and universities.

The differences between the 40-44, 46 and 47 strings pedal harps are the size, weight and sound power, besides the amount of strings. In this research we will focus on the 47 string pedal harp, or concert grand harp. It is worth noting that the same technique explained can be applied on 40, 44 and 46 string pedal harps, observing the amount of strings of the respective instruments.

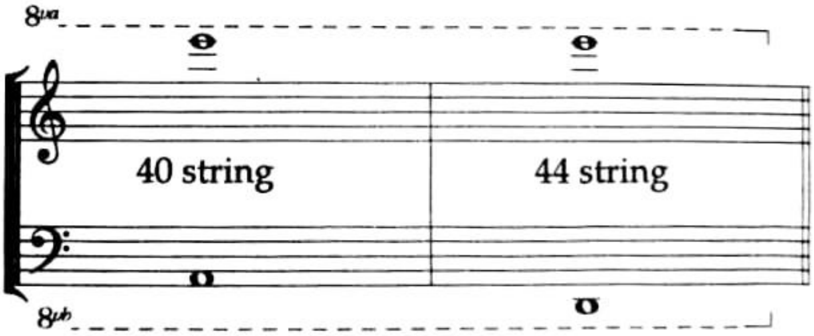


Figure 9. Petite Harp range, 40 and 44 strings (REES-ROHRBACHER, 2002, p.10).

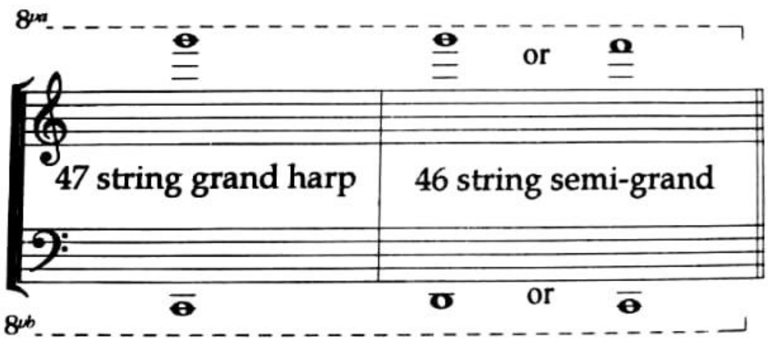


Figure 10. Concert grand harp or pedal harp range, 47 strings and Semi-grand harp, 46 strings (REES-ROHRBACHER, 2002, p.9).

Figure 11. Pedal Harp. Salvi Minerva 47 string (SALVI HARPS).

2.2 Strings

The 47 strings of the pedal harp are divided into 6 octaves of C major (C1[2] through C7) and a seventh incomplete octave from note C7 to note G7. For historical reasons of inheritance from the predecessor instruments, harp strings have another code and are counted in octaves of F. Due to the large number of parallel strings, a color-code is used to identify the octaves and notes. All C strings are red and F strings are black or dark blue. In this way, the harpist visualizes patterns or grouping, i.e., portions of strings of his/her instrument as a reference for playing.

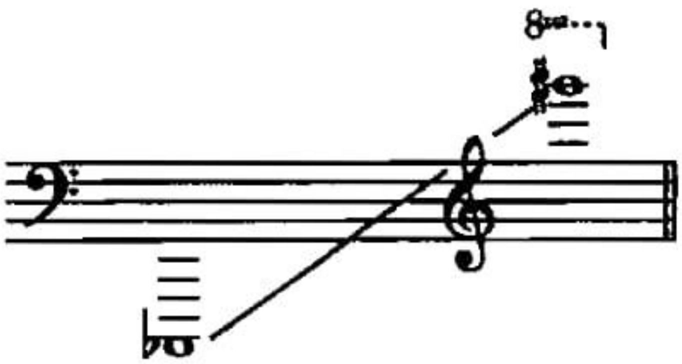


Figure 12. Pedal harp range (ADLER, 2002, p.90).

The pedal harp has different types of strings with different sound qualities:

• Lamb gut string: produces wide, high-quality sound. Much used in the central range of pedal harps.

• Nylon string: has no as sound power and amplitude as the gut strings. It has an opaque sound, but because it is more resistant, it is widely used in places with little thermal stability. Much used in the highest two octaves of pedal harps.

• Wire string: used in the two lowest octaves of pedal harps (C1-G2). Due to the tension caused by the strings in that region, there are no other suitable types of material.

[2] C4 = middlle C / C4 = 262Hz

2.3 The Hands on the Harp (As Groups of Notes)

The technical position of the hands on the harp is like hands that would be ready to give someone a compliment, i.e., “the position is similar to hand extend, as if ready to shake hands, but with the fingers turned inward.” (CHALOUPKA, 1979, p.04). So the fingers are placed on the harp strings, except for the little fingers that are not used to play the pedal harp. This is the best and most accepted way to pluck naturally the strings. Such position is used on both hands, and every pedal harp technique is developed upon this basic position (CHALOUPKA, 1979).

The harpist has a basic “hand form” that must be trained. The difficulty of playing the harp is that the harpist's hand must “draw” patterns by articulating with the fingers on the strings. Koechlin (1954), explaining pedal harp writing, mentions the use of "a great number of drawings" (p.121) of possibilities for writing, i.e., the hand is suspended with the fingers drawing structures corresponding to the arrangement of the figures on the score.

The right hand on the harp plays usually the melody written frequently in the treble clef. The playable range of the right hand is from G2 to the highest strings (figure 13). The left hand on the harp usually plays the harmony and is usually written in the bass clef (figure 14). Its playable range is the entire register of the harp. In certain passages, one can alternate hands, both hands can play in parallel chord sequences (CHALOUPKA, 1979; REES-ROHRBACHER, 2002).

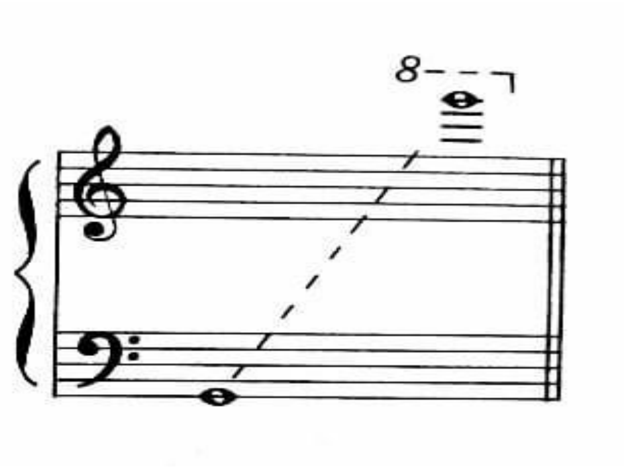


Figure 13. Range of right hand on the pedal harp (CHALOUPKA, 1979, p.5).

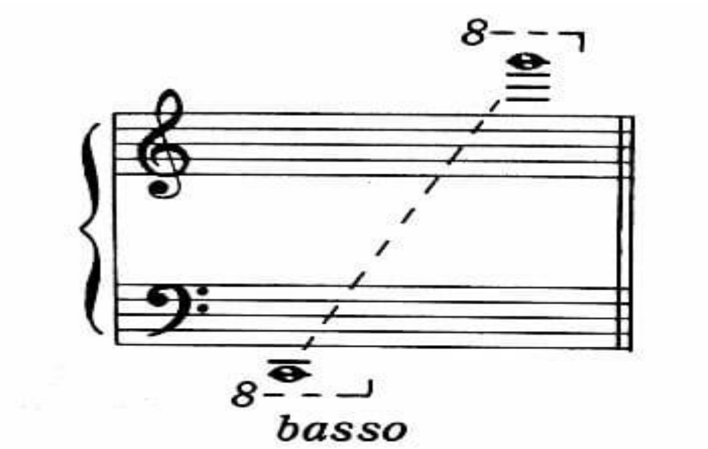


Figure 14. Range of left hand on pedal harp (CHALOUPKA, 1979, p.5).

Formerly, the melody was characteristic of the left hand, as in any other string instrument. However, the use of the right hand for the melody came as inheritance of keyboards instruments because there was a shortage of the harp repertoire.

The vast repertoire of the keyboard instruments was used by the harpists. Those instruments had similarities with the harp in the diatonic arrangement of the notes, i.e., the arrangement of the white piano keys (C, D, E, F, G, A, and B). The black keys of the keyboard instruments that refer to chromaticism are played on the harp with the help of pedals (this point will be discussed later). Thus, the ancient technique of the harp was modified, resembling the writing of keyboard instruments.

The change of register can be written on the same stave, pointing up the stems of notes played by the right hand, and down the stems of notes played by the left hand (figure 15). Each group of notes can be written with stems down or up according to the register and hand. The range of the notes used by each hand should not exceed one octave. We do not use notes with many supplementary lines, usually indicating them with the “octave above” and “octave below” symbols.

Figure 15. Musical example: both clefs are used at the same staff when the harp is played, i.e., both hands are played in the same register (RAVEL, 1925 apud KOECHLIN, 1954, p.120).

An indispensable observation is that, there are ways for the harpist to read those figures (figure 15). One is to place the four fingers at once on the strings, from one hand to the other. This is a rule for descending arpeggios. Another possibility is the sequence of notes to begin in the low register (ascending, which would be the opposite of figure 15), then the left hand would be placed in the sequence, with notes from one finger to another, or also from one hand to the other.

2.4 Fingers – As Groups of Notes

In the modern harps the strings are plucked with the fingertips, not the nails. Nails are used in folk harps, namely: Paraguayan harps and Irish harps (small harp with metal strings). Therefore, due to anatomical reasons, the use of the little finger of both hands was excluded from the fingering of the pedal harp for a better technical development.

The harpist uses four fingers in each hand. To the thumbs are directed the highest notes, followed by the second fingers (index fingers), third fingers (middle fingers) and the fourth fingers (ring fingers) leaving to them the lowest notes[3]. The placement of the fingers on the harp usually starts from the lowest note to the highest note, i.e., in a four-note chord, the ring fingers will play the lowest note of a chord. In a

[3] Arabic numerals refer to the fingers of both hands: 4 = ring fingers 3 = middle fingers, 2 = index finger, 1 = thumbs.

three-note chord, the middle fingers will play the lowest note. It would be like the fingering of the left hand on the piano to both hands, with no use of the little fingers (CHALOUPKA, 1979; REES-ROHRBACHER, 2002).

As already mentioned, harp reading begins from the lower notes on. So, the fourth (ring) fingers play always the lowest, following by the third (middle) fingers, second fingers (index fingers) and thumbs that play always the highest notes. And if the opposite occurs, as in figure 15, the thumbs will have primacy followed by the other fingers in sequence. The fingers attack all the strings like a grouping. Piston (1969) writes that:

> On the harp there are no fingering patterns such as those occasioned by the arrangement of black and white keys on the piano keyboard. All scales are fingered alike – ascending 4321 [left hand] 4321 [right hand], descending, 1234 [right hand] 1234 [left hand], etc. (PISTON, 1969, p.330-331).

2.5 Intervals between the Fingers

A hand on the harp can pluck at the most a 10th interval (CHALOUPKA,1979; KOECHLIN, 1954; MILLER, 2015; REES-ROHRBACHER, 2002). In the moment the harpist needs fingers to complete a chord, the other hand immediately assumes the responsibility for the remaining note(s).

A maximum range interval for each hand on the harp is between the fourth and third fingers (annular and middle fingers) for lower notes, and second and first fingers (index fingers and thumbs) for higher notes, avoiding large intervals between the third and second (middle and index) fingers.

Figure 16. Position of the hands on harp strings: left hand followed by right hand (JORDAN, 2007).

Eventually the left hand can exceed the 10th interval. In such situation, the harpist does not place all fingers of the left hand on the strings at the same time, but plays note by note, placing each finger at a time. If the left hand had to play a chord in *non arpeggio*, it would not be possible to exceed a 10th interval.

Playing a succession of fast notes with the stretched hand is not natural, especially considering that the technical support of the harp is to pluck strings (not pressing them), so the succession of fast notes with maximum extension is to be avoided. Therefore, it is advisable to avoid the succession of fast notes with maximum extension of the hands.

2.6 Chords and Variations

The chords on the harp are always *arpeggio*. Salzedo (1917) writes that "all chords not preceded by a special sign must be slightly *arpeggio*." (p.2). When a longer *arpeggio* is desired, it is written as a symbol corresponding to the *arpeggio* symbol (figure 17). The composer can write *non arpeggio*, using the symbol [in the extension of the chord (figure 17). Such procedure is recognized as exception, not as rule.

The note that falls on the beat is usually the lowest note of the chord. When it comes to orchestral works and chamber music such rule is controversial, it depends on the experience of the composer in writing and the interpretation of the group. The arpeggio direction must consider what comes before or after harmonically and melodically so that the ornament does not disturb the harmony or the phraseology of the work. Chaloupka (1979) suggests that "this may be indicated by an arpeggiando sign with an asterisk at the bottom (*) preceding the chord." (p.8).

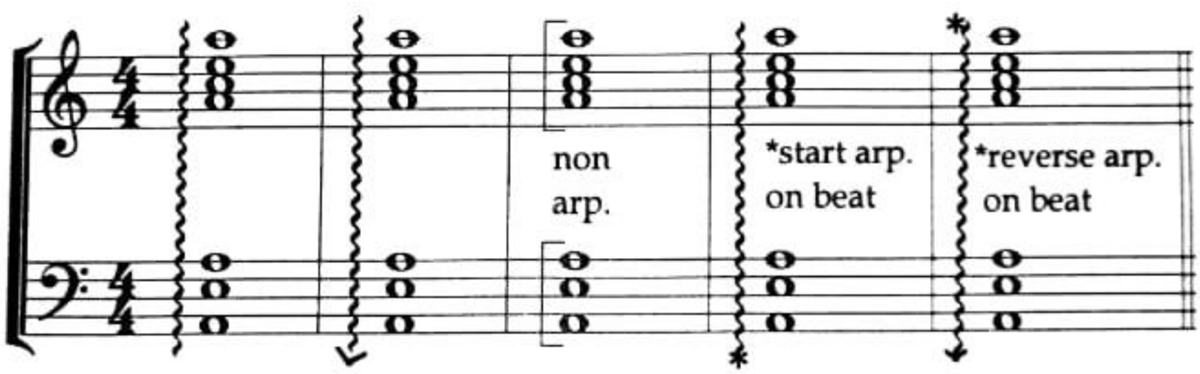


Figure 17. Chord on the harp (REES-ROHRBACHER, 2002, p.49).

Great chords in shape of great *arpeggios* on the harp are common. In such cases, chord notes are distributed between both hands. However, Chaloupka (1979) advises us to omit a note in the left-hand chord. For reasons of sound resonance, by doing so, we give space for harmonic sounds (harmonic series) to associate with natural sounds and thus it sounds clearer (figure 17). The harp is a harmonic instrument. Chaloupka (1979) suggests some chord guidelines:

> 1.The span of the chord should not exceed an 11th. In a 4-note chord the interval between the two bottom notes should not exceed a fifth. In a 3-note chord the interval between the two bottom notes should not exceed an octave.
>
> 2. Block chords (non arpeggiando) should not exceed a total span of a 10th.
>
> 3. P.D.L.T. (*près de la table*) chords, meaning that they are played near the soundboard, should not exceed a total span of an octave. (CHALOUPKA, 1979, p. 5)

Shaking chords (tremolo chords) also called *bisbigliando* (murmuring) are played alternating quickly the hands (figure 18). Associated with enharmonic notes the effect has a clear sonority. It can also be used in one hand, but the best effect of *bisbigliando* is obtained by alternating both hands.

Figure 18. *Bisbigliando* on the harp (REES-ROHRBACHER, 2002, p.34).

Effective trills on the harp are played with two alternating hands, like the *bisbigliando* chords (figure 18 and 19). The one-hand trill is not advisable, but is also used. The use of enharmonic notes for trills is of great value, they give more definition to the trill.

Figure 19. *Trills* on the harp (REES-ROHRBACHER, 2002, p.33).

The most suitable region for trills is the treble region due to acoustic reasons. The shorter the string the less its vibration time, therefore due to the speed of finger replacement, the greater possibility of sound. Whenever possible, the use of enharmonic notes is advisable in order to achieve a clear sonority.

The great *arpeggio* is written following the rules of the extension of the hands and the intervals between the fingers (figure 20), alternating both hands.

Figure 20. Chords written in great arpeggio. Ravel (1905) wrote the division of hands. (RAVEL, 1905, p.2).

2.7 Scales

The technique used to play a scale is the same for all types of scale, i.e., in tonal, modal, atonal, chromatic, and pentatonic contexts. When possible, the same finger arrangement is used, but with interval differences (i.e., 4321 left hand, 4321 right hand).

The strings to be played are always the same, for example, the note C, C# or C*b* are played in the same string, and so on, what changes are the notes pressed in the pedal groove, i.e., pedals are used to give new tones and semitones (see below item 2.9). Therefore, the shape of the hand to play the notes of a scale are arranged in the same way.

The *glissandos* can be written with lines that indicate their range (figure 21). Such lines can be precise or not, i.e., with or without start note and end note. The notes can be represented by a pedal diagram (see below item 2.9), or written on a small scale in parentheses on the staff, or with letters below the staff.

Figure 21. Scale and Glissando (REES-ROHRBACHER, 2002, p.51)

The *glissandos* are a variation of the scales, simply modifying the speed of its execution with the sliding of fingers on the strings (KOECHLIN, 1954). Glissando can be done with one or two fingers of each hand or combining both hands. This means that with the use of pedals we can make a series of variations on the *glissandos*, including enharmonic notes. So that we can play a scale or *glissando* chord just operating the pedals and sliding the fingers on the same strings (RIMSKY-KORSAKOV, 1964).

Schlomovitz (1978) suggests writing pedal diagrams (see below item 2.9) for major enharmonic scales. With the help of note (pedal) enharmonization is possible to play glissandos of chords (figure 22 and 23). For example: in the Bb major key, it is possible to sharp the E and A strings; in the D major key, it is possible to flat the C and G strings. In the case of the C major key, the B string is played as B# and the F string is played as Fb (figure 22 and 23).

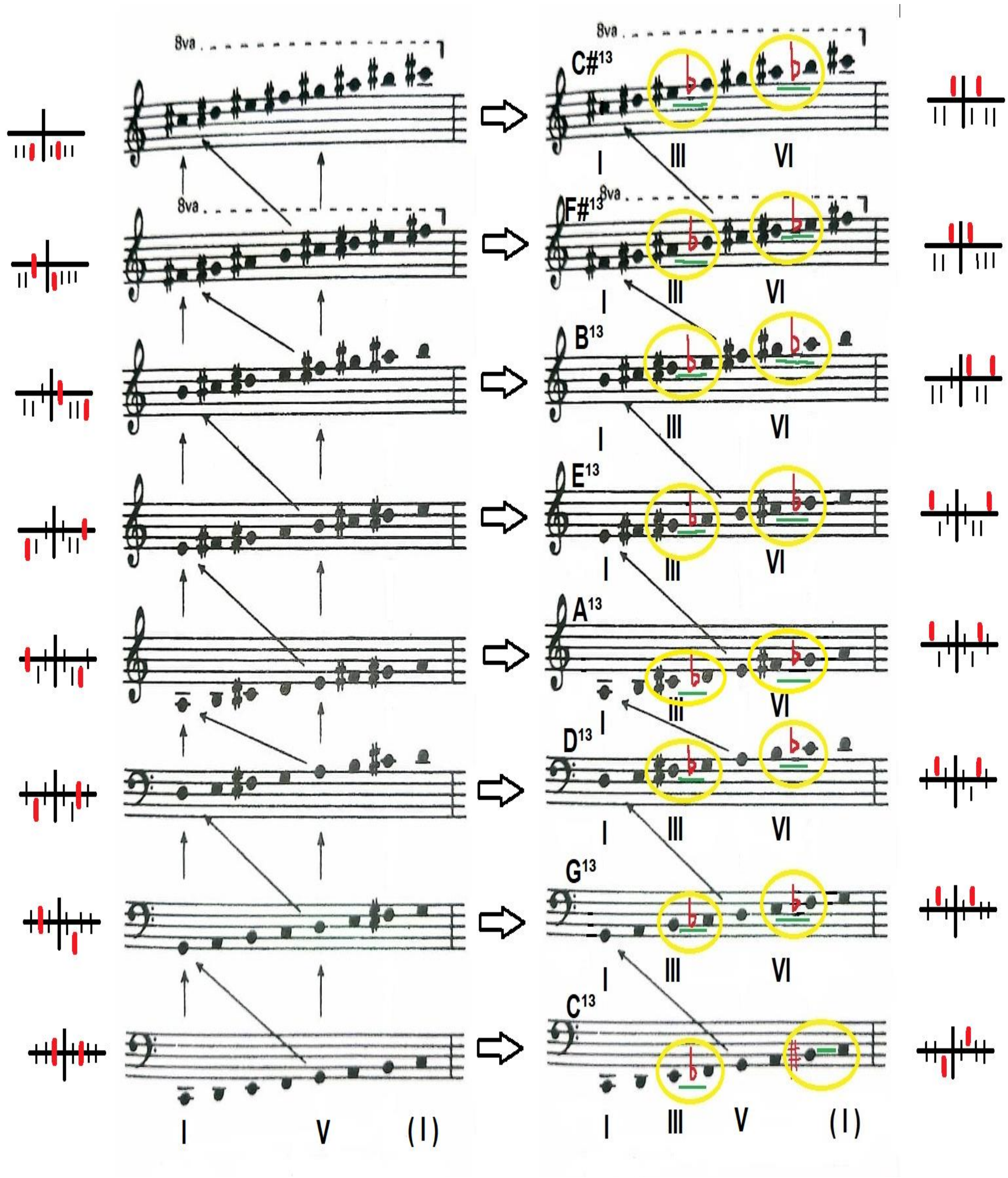


Figure 22. Suggestion for major scales enharmonic glissandos on the harp: the process of enharmonization becomes glissandos of chords. Figure constructed according Schlomovitz (1978).

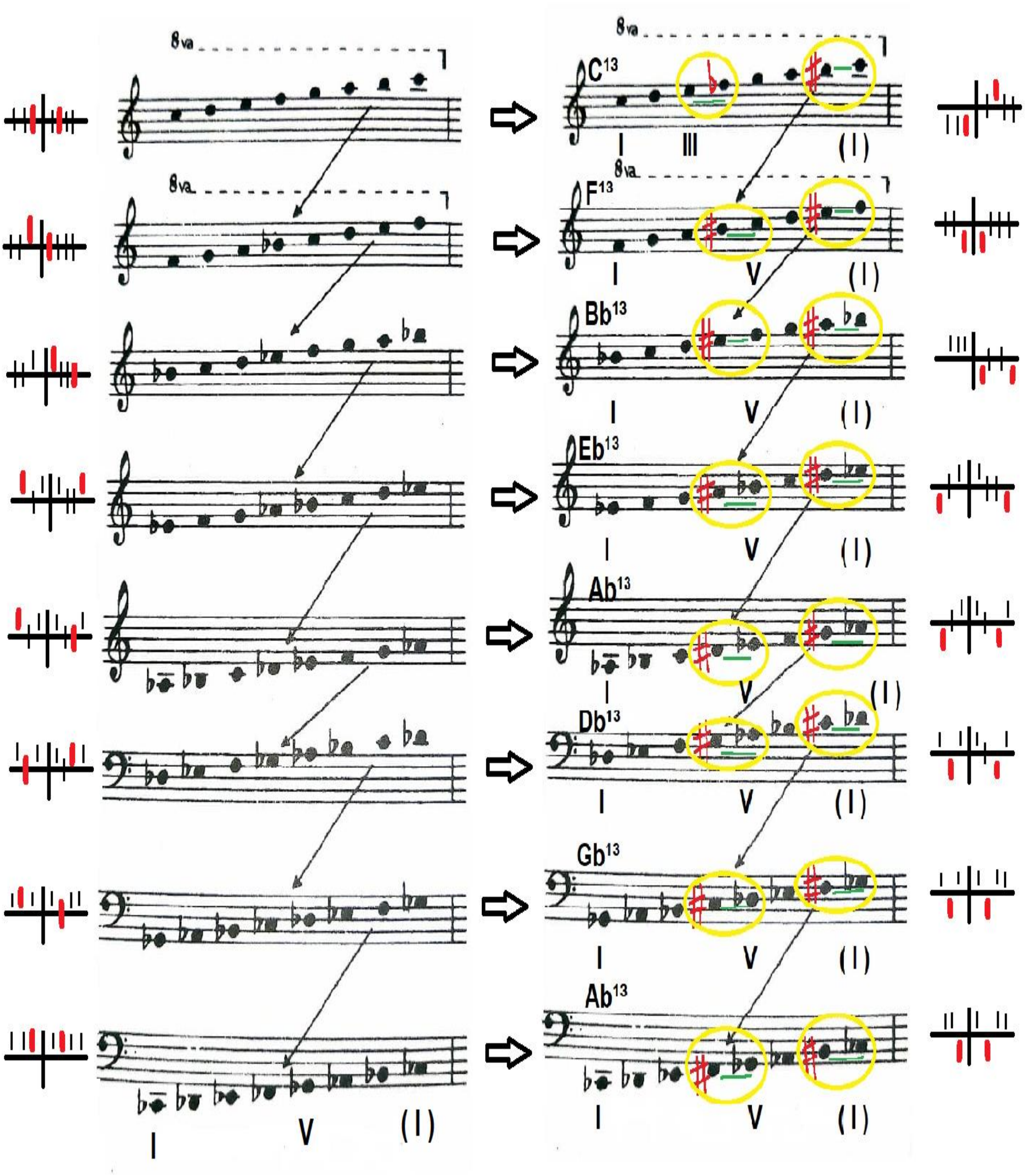


Figure 23. Suggestion for major scales enharmonic glissando on the harp, the process of enharmonization become glissandos of chords. Figure constructed according Schlomovitz (1978).

2.8 Harmonics

Harmonics on the harp, i.e., notes that sound an octave up, are played in the middle of the string being simultaneously muffled with the same hand. They are indicated with a small circle above or below the actual note. The range of harmonics on the harp is indicated in figure 24. Harmonics below or above this range do not sound. However, harmonics played on strings of wire below the range sound like dry notes emitted from a marimba. In this region it is advisable to use one note at a time for a reasonable sound emission.

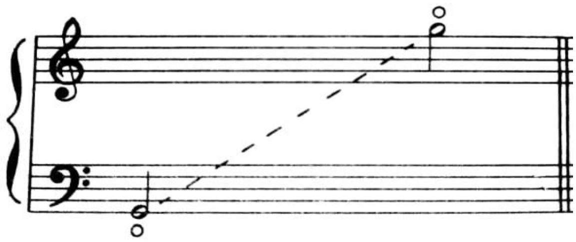


Figure 24. Range for harp harmonics (CHALOUPKA, 1979, p.12).

Harmonics can be played as single notes, or by both hands. The left hand can also play two notes with the maximum interval of four and three notes, and triads in the fundamental position. The right hand can play only one harmonic at a time: the harp rests on the right shoulder of the instrumentalist, so the right arm is limited to playing only one harmonic. The right hand can play harmonics in conjunction with left hand (figure 25). It is possible to combine natural sounds with harmonics, even in *glissandos*.

Figure 25. Possibility of harmonic sound (ALEXANDER, 2008 p.688).

2.9 Pedals

One of the fundamental principles for harp writing is the use of pedals. A feature to facilitate the reading of the pedals is a diagram of the pedal arrangement (figure 26). It is written every time when a new pedal arrangement is required. Another way to write such pedal arrangements are pedal/note letters below the staff or a small scale in parentheses in the score, in case of glissandos, for example.

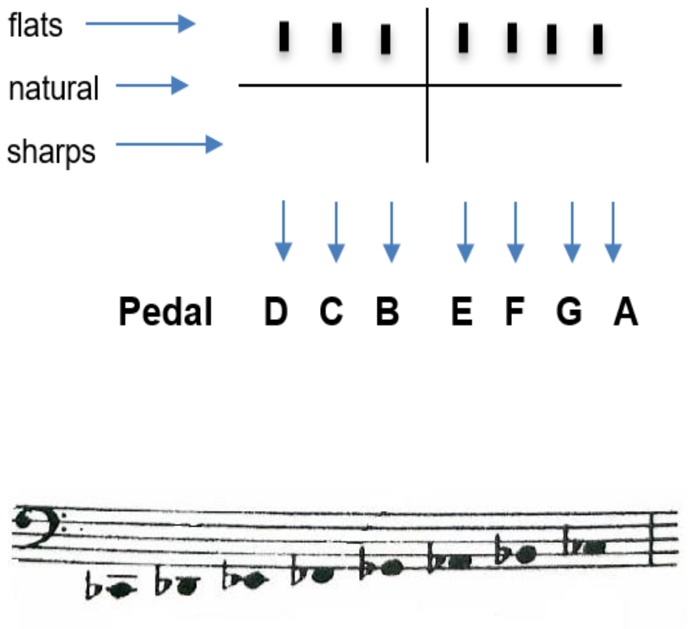


Figure 26. Pedal harp diagram, and musical pentagram with the C-flat major scale corresponding to the pedal diagram in the example.

The most common are the use of the diagram and pedal/note letter. The composer does not have to worry about pedal indication or pedal diagram, but he must be aware that the modulations and cancellation of tones need to be done separately from the fingering of the hands. The composer must also remember the diagram arrangement to proceed modulations and accidentals in the score. Adler (2002) however suggests that: “It is important to memorize the arrangement of pedals on a harp, as well as which foot operates which pedal” (p.91). The diagram corresponds to the movements that the foot makes with each alteration of the note of the sheet music.

The harp has seven pedals, one for each note of the diatonic scale (C, D, E, F, G, A, B). The arrangement of the pedal harps is not in the sequential order of the scale (figure 26). We have three left side pedals that correspond to the D, C, and B strings (with three grooves for each pedal, corresponding to flat, natural and sharp), and four right side pedals E, F, G and A (also with three change possibilities for each note/pedal).

Two pedals, one in the right foot, another in the left foot can be operated simultaneously, respecting the arrangement of the pedals (DCB / EFGA). For example, change pedal D# to D*b* (right foot) and natural pedal G to G# (left foot).

The pedals are responsible for all chromatic changes on the harp, they flatten and sharpen the diatonic strings of the instrument. For example, if we are in C major, all notes of the harp will correspond to the key of C major and all pedals will be in natural position (figure 27).

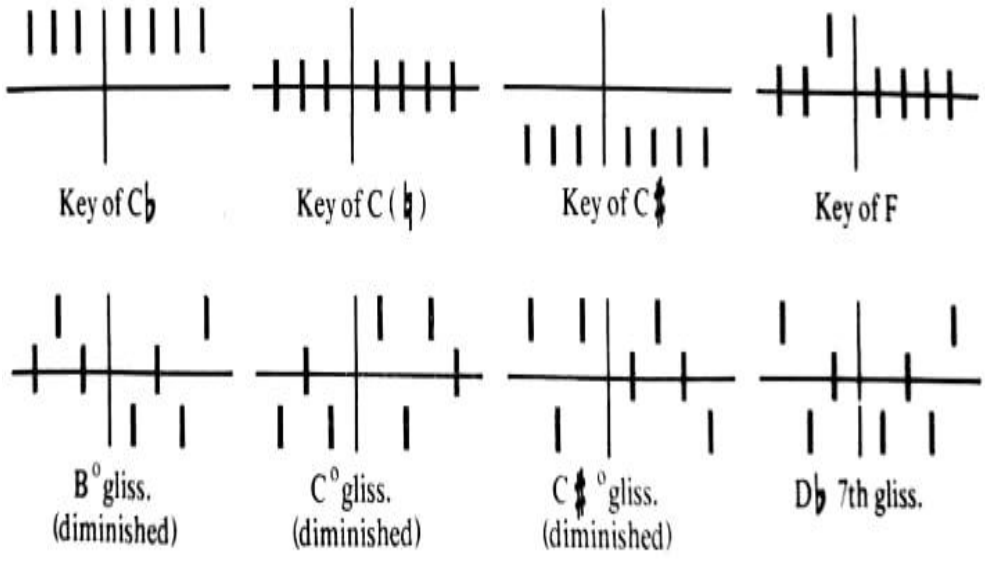


Figure 27. Possibilities of pedal harp diagrams (CHALOUPKA, 1979, p.19).

Remember that if the C# pedal is pressed, all the C's of the harp will become C#. The same is valid for each note, so the use of enharmonic notes is of great value. The tuning of the harp is C flat, i.e., all the pedals suspended up (figure 26 and 27).

The pedal harp was built especially for the musical demands of the tonal system. In the tonal system we have two basic ways of changing diatonic notes: flatten and sharpen. So, we have a groove for each pedal/note that corresponds to such changes, besides the natural groove (the double sharps or double flats is played with enharmonic notes, see below).

Natural A, G and D cannot be doubled enharmonically (figure 28). And notes C1 and D1 (last two lower notes of the harp) and G7 (last treble note of the harp), because do not have a pedal mechanism, can only be tuned manually with a tuning key.

This note:	**C**	**C#**	**D**	**D#**	**E**	**F**	**F#**	**G**	**G#**	**A**	**A#**	**B**
is the same as:	**B#**	**Db**		**Eb**	**Fb**	**E#**	**Gb**		**Ab**		**Bb**	**Cb**

Figure 28. Enharmonic notes. (MOORE,2002, p.4).

To write for harp the knowledge of enharmonics shows an observable resource (KOECHLIN, 1954; MILLER,2015). For example, C major scale is the same as B# major scale, etc. (figure 29). Schlomovitz (1978) suggests a sequence of major scales based on the Circle of Fifth, with changes of just two pedals per key, (figure 30 and 31), and writes that:

> Transposing a ½-tone up or down (from a flat key to a natural key, or a natural key to a sharp key, as key of Gb to G#, or Eb to E) can be done very easily on the Harp, if a careful plan of pedal changes is worked out. The usual transposition are done by up or down the scale by keys. In doing this, you will be playing every other key in the cycle of fifths, and each key change will require two pedal changes. (SCHLOMOVITZ, 1978, p.1)

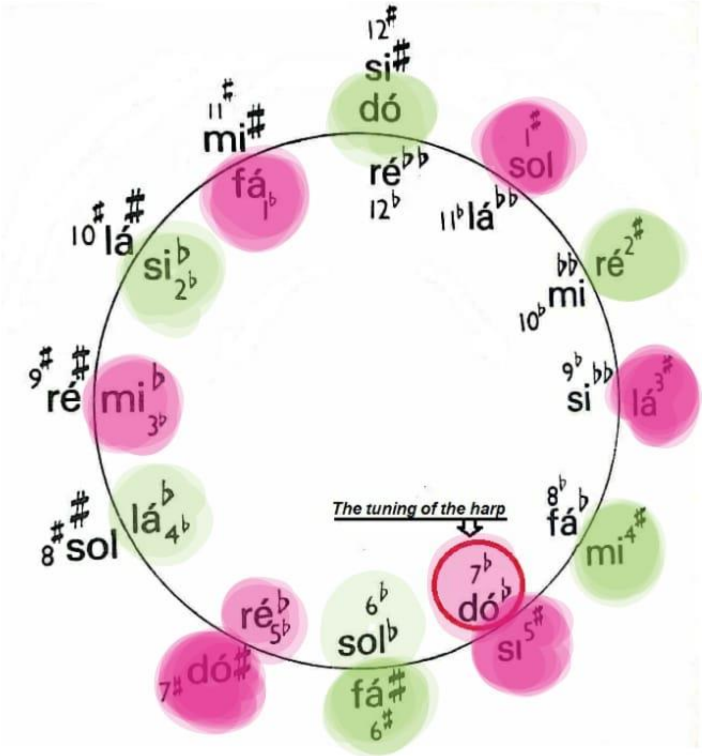


Figure 29. Adapted figure Circle of fifths, see figure 30 (pink) and 31 (green). (KÁROLYI, 2015, p.49).

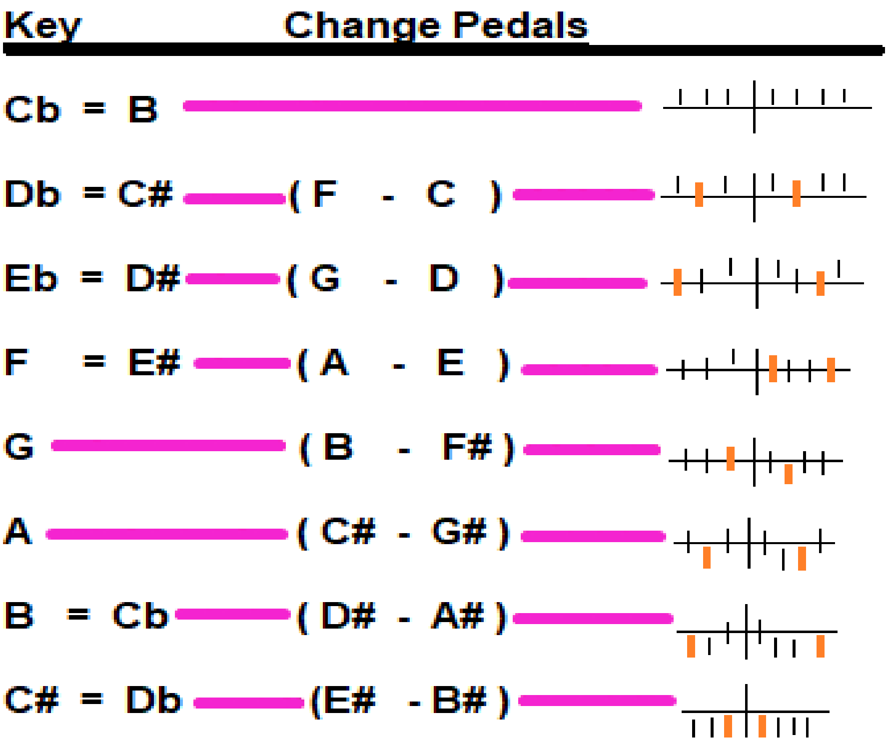


Figure 30. Adapted circle of fifths - from the key of C flat major. A sequence of major scales based on the circle of fifths, with changes of just two pedals per key (SCHLOMOVITZ, 1978).

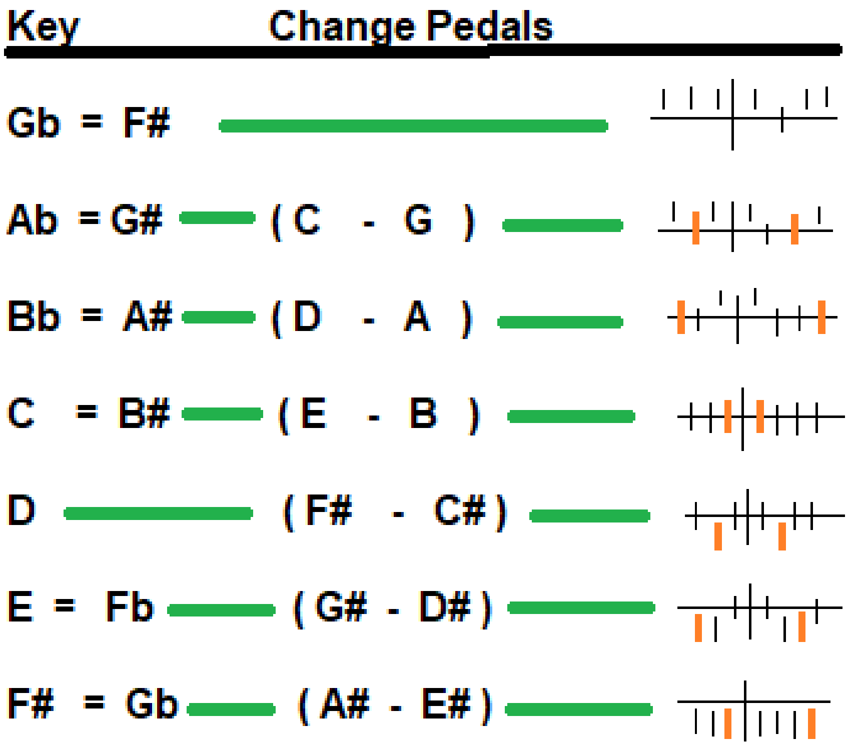


Figure 31. Adapted circle of fifths - from the key of G flat major. A sequence of major scales based on the Circle of Fifth, with changes of just two pedals per key (SCHLOMOVITZ, 1978).

The use of the pedal provides possible modulations and possible accidentals. Remembering that the arrangement of the strings is static (figure 32 and 32b), and arranged in a diatonic manner, depending only on the fingering of the hands.

Figure 32. Enharmonic suggestion (REES-ROHRBACHER, 2002, p.36).

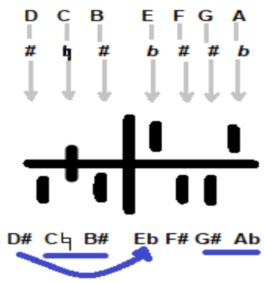


Figure 32b.The diagram of the pedals arrangement for the figure 32.

In the case of tonal music, it is advisable that the harmonic progression follow the harmonic conduction of the circle of fifths (SCHLOMOVITZ, 1978). Because the pedal harp is a tonal instrument, the pedals (accidents/modulations) are conducted more naturally following tonal principles such as, for example, the relative chords, as well as anti-relative (figure 33), and the relationship of the secondary dominant chords in the circle of fifths (figure 34).

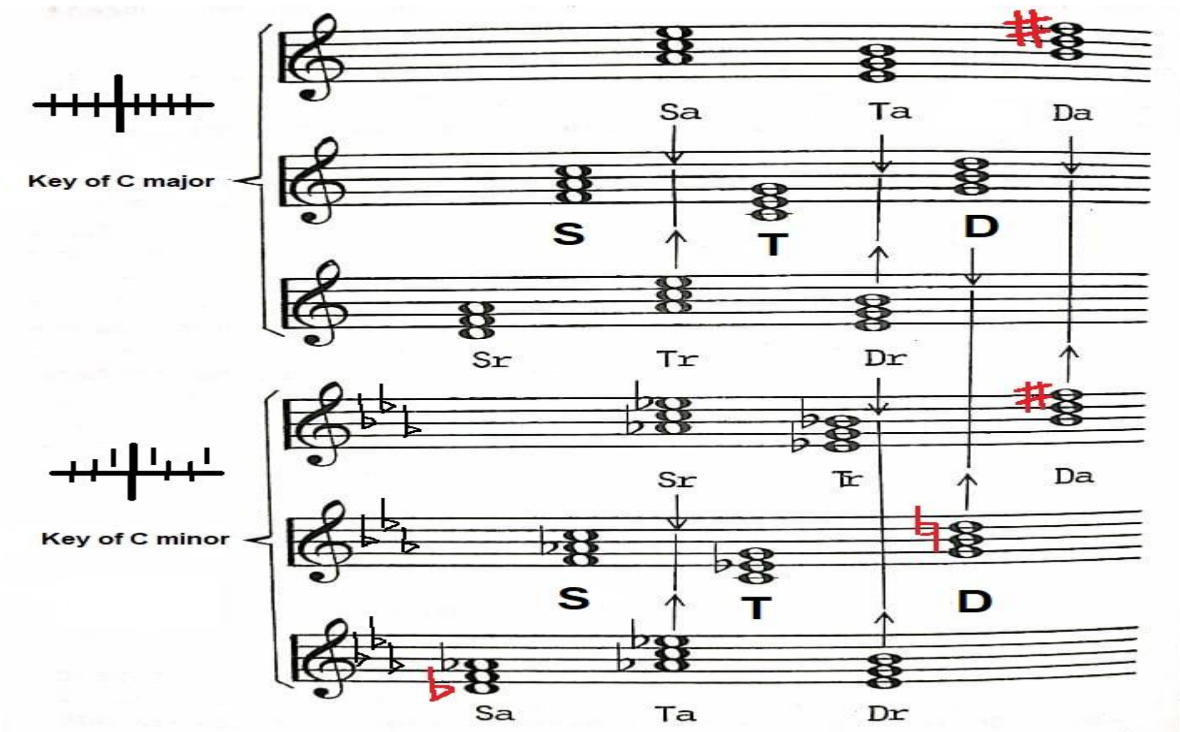


Figure 33. The principle of changes in relative chords, as well as anti-relative. The neighboring chords of third, lower or upper, are related to the main functions (in the first degree – Tonic –, fourth degree – Subdominant –, and fifth degree – Dominant) as relative and anti-relative. Accidents in red represent pedal changes. (BRISOLLA, 1979, p.66).

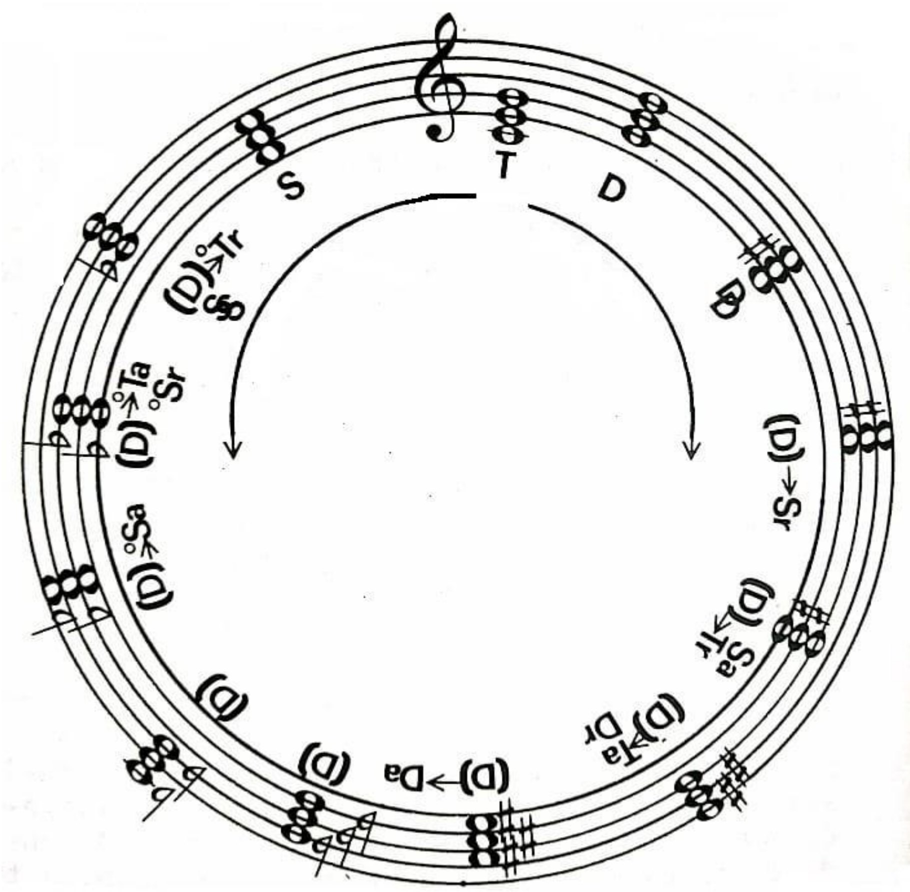


Figure 34. Relationship of the secondary dominant chords in the circle of fifths, i.e., the chords of the harmonic center has its own dominant (fifth degree). Accidents follow the conduction of harmonic functions, being a parameter for placing or canceling the pedals (BRISOLLA, 1979, p.72).

Modulations/accidentals must be prepared or synchronized with the rhythm of the hands, both to modulate or to cancel, i.e., pedal changes should preferably be synchronized with time (pauses, for example) or rhythm of the work. Salzedo (1917) writes that:

> Every unnotching of the pedals is scrupulously indicated in accord with the rhythms of the musical expression. By conscientiously taking note of this, one will acquire two things important in themselves and necessary to interpret faithfully the musical thought. First of all, the pedals will cease to occasion special solicitude, and thus the needless worry they cause will disappear. Then, also, owing to their correspondence with the musical accentuation (aesthetically and sonorously considered) the movements of the feet will no longer be left to chance. The action of the pedals can thus be controlled in a manner both unnoticeable and silent (a most important matter), and the ensemble of the player's gestures will constitute a **whole** indissolubly harmonious and essentially artistic. (SALZEDO, 1917, p.4-5, bold in original).

2.10 Aspects of Harp Sound written in the Sheet Music

2.10.1 The Sound of Harp

The harp has greater sound power in the C major flat tone, because its strings are all loose vibrating without any mechanical restriction, without any mechanism shortening them. When possible, it is convenient to write for harp in flat keys rather than sharp keys.

Some researchers say that the sound of the harp is more sostenuto (REES-ROHRBACHER, 2002; CHALOUPKA, 1979). However, such conception depends on the register: in high range (where the strings are short and thin) this assertion cannot be supported. It is impossible to sustain a note for long time on the harp. The vibration time depends on the size of the string. If it is short its sound finishes quickly. If the string is longer, it will vibrate a certain time more, but with no loud intensity.

The best sound range of the harp is written in treble and bass clef (without supplementary lines). But this does not mean that it will have a continuous sound. After plucking, the sound undergoes an intensity decay. Notes written in the supplementary lines below the bass clef or notes written in the line above the pentagram of the treble clef have sound restrictions.

The areas that have the most penetrating sound are written above the staff in the treble clef, because “the sound of notes in the highest register of the harp is penetrating and quite percussive” (CHALOUPKA, 1979, p.5) The notes written below in the staff in the bass clef have no penetrating sound because they are very rich in harmonics. Chaloupka (1979) writes that: “notes below the staff in the bass clef progressively diminish in carrying power. The lower the note, the less it carries” (p.5).

In order to have a clearer sound in the lower register of the harp, the player usually plays closer to the resonance box, producing a “drier” sound. In order to avoid excessive reverberation in this range, the composer can request the French acronym P.D.L.T. (près de la table).

The way to pluck the harp strings is only one, what can really be different is the intensity and speed of plucking and dampening. Other sound observations nuances can be considered technical peculiarities (KOECHLIN,1954).

Chaloupka (1979) writes that the *legato* on the harp is practically natural because every fingering that is used has the legato intention. Although the *legato* on the harp may be questioned by the fact that the instrument is played by plucking the strings.

In the case of "*staccato* effect upon the harp, individual strings must be damped immediately after they are plucked" (CHALOUPKA, 1979, p.26). They can be written between the stave, or in the register in which it is desired to muffle the sound. Alexander also writes that:

> With this technique, the vibrations of the string are stopped once produced creating the effect of violin or viola pizzicato. The passage is played staccato to accommodate the effect. (ALEXANDER, 2008, p.696)

2.10.2 Muffled Notes

On the harp, whenever possible, the notes, chords and *glissandos* are muffled after being played, because their sound does not finish quickly. Salzedo (1917) emphasizes "the peculiar instrumental character of the Harp, considered from the point of view of the 'arrest of vibration' and production of tone" (p.2). The notes continue to sound until the strings stop vibrating, which takes a considerably long time (depending on register), and may interfere with the other harmonies played next. Pauses and instructions to muffle notes should be considered. The symbol for muffling notes corresponds to the same symbol of the coda.

Repeating the same notes on the harp successively is counterproductive, because to play a note the player must pluck the respective string successively. By plucking a string, its sound is interrupted when you put your fingers to pluck it again. In this way, it is no possible to keep the sound continuously sounding in consecutive notes, because with each new attack the vibration of the string is cut. Macdonald (2004) writes that: "The playing of successive notes of a chord, going up or down, is well within the natural capacity of the harp, in fact it is its Italian name ‘arpa’ which gives these harmonic patterns the name ‘*arpeggio*’” (p.70), i.e., successive notes of a chord, played up or down. The use of enharmonic notes is the solution to the problem of repeated notes.

On the harp, we have the advantage of using enharmonic notes by virtue of pedal action. This helps to avoid types of buzz replacing the fingers in the strings, which are nothing more than the sudden muffling of strings vibration. The breaking of the vibration produces a noise that can be avoided with the use of enharmonic notes.

2.10.3 Harmonic Voices

Many voices writing on the harp, with a complex harmony, is also counterproductive. Due to its continuous resonance, its sound does not completely extinguish after being plucked. There is a mixture of sounds, or rather of tones, many harmonic voices are not advisable for reasons of resonance. It is advisable to avoid the use of many harmonic voices.

Contrary movements of voices on the harp should be avoided. So, the parallel movement of voices and chords is advisable. The use of consecutive thirds is inadvisable, it will sound better in fourths, sixths or tenths, that is, inverted thirds give greater amplitude of sound (CHALOUPKA,1979; KOECHLIN, 1954; REES-ROHRBACHER, 2002). However, Macdonald (2004) writes about consecutive intervals in rapid succession that they “can be played only descending, enabling the thumb to slide from one upper note to the next while the lower notes are taken by the other three fingers” (p.71).

Figure 35. Consecutive intervals in rapid succession with one hand. (MACDONALD, 2004, p.71)

Four notes together in each hand of the same chord sound unclear, due to the timbre of the harp having a great deal of harmonic resonance. For greater clarity it is better to omit a voice in the chords of the left hand. On the harp, the less voices the better sound, the use of the vast and rich extension of the instrument is advised not to be directed to only one register.

The use of the octaves, instead of single notes, will give greater sound amplitude. It is advisable to avoid the use of consecutive or skipped octaves in a quick sequence, preferring to write passages where the player can alternate two hands, or both hands touch parallel octaves (right hand playing octave above left hand).

2.11 Closing Considerations

The writing techniques for pedal harps discussed here refer to the writing of tonal music in the pedal harp from Erard (1810) to the modern period. The modern period was the apex of the writing of the pedal harp with French Impressionism, with Ravel (1905), for example. Another movement that began in the modernism and culminated in postmodernism, after Second Great War, that looks for other resources for sounds in the pedal harp was initiated in by the researches of Carlos Salzedo (1917). It is the so-called expanded techniques which adds noises to the emission of natural sounds.

In chapter 4 we will observe more closely the fundamental pedal harp writing at the beginning of modernism which was considered the boom of the development for the pedal harp writing. We will approach excerpts from three works written for pedal harp: Concertstück for harp and orchestra, Op. 39, by Gabriel Pierné (1901), Introduction and Allegro, by Maurice Ravel (1905), and Concerto para harpa, by Heitor Villa-Lobos (1953).

3 FROM SENSATION TO VISUAL AND AUDITORY PERCEPTUAL ORGANIZATION – COGNITIVE-NEUROSCIENTIFIC APPROACH

3.1 Visual System

3.1.1 Psychophysical Aspects

The psychophysical aspects of visual system embrace the pathways of the visual information from eyes until the brain. After being processed by the visual system (eyes), the visual information becomes neuro-electrochemical impulses by the transduction – produced by the activity of neurons responsible for the encoding of light stimuli. The electrochemical signals reach the Lateral Geniculate Nucleus (LGN) in Thalamus, responsible for distributing visual information to the visual cortex in occipital lobe – parietal lobe and lower temporal lobe where they will finally be decoded and understood (figures 36 and 37).

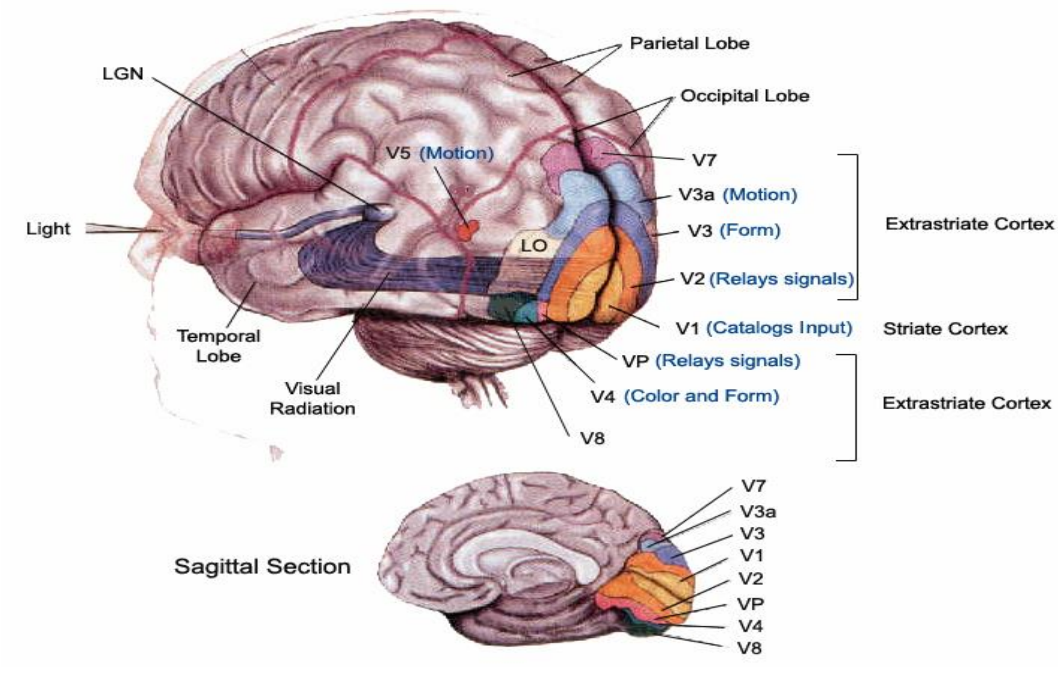


Figure 36. Visual Cortex subdivided by specialized regions. The light enters through the eyes. Through the transduction process, the electrical signals are transmitted to Thalamus (in the Lateral Geniculate Nucleus, LGN area) and then it is distributed to specific regions of the visual cortex (RHAWN, 2000).

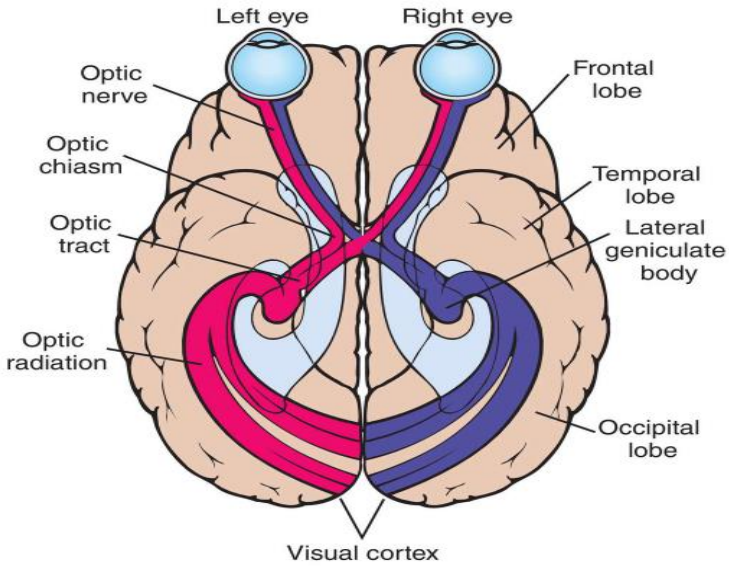


Figure 37. The visual information becoming neural electrochemical impulse developed by the transduction, distributing visual information to the visual cortex (LEWIS et al, 2007).

According to McBride and Cutting (2019), such process has correspondence to the other organ processes of the sensory system, i.e., "a system that receives and processes input from stimuli in the environment" (p.93) in four stages. In the case of the visual-sensory system, the stages are: "(1) sense organ – the eye, (2) receptor cells – the rods and cone in the retina [where transduction occurs], (3) nerve conduit to brain – optic nerve, and (4) brain areas where information is processed – primary visual cortex (also called V1) in the occipital lobe of the brain (with extensions to other areas to connect with other cognitive processes)." (MCBRIDE; CUTTING, 2019, p.92). Mack (2013) writes that:

> The brain […] is where seeing happens; it is the brain that figures out what the clues mean. Thus visual perception is a creation of the brain. It is based on the input extracted from the retinal image. But what is seen in the "mind's eye" goes far beyond what is presented in the input. The brain uses information it has extracted previously as the basis for educated guesses—perceptual inferences about the state of the world. Sensory systems contain many representations that each specialize in different kinds of sensory information processing. Throughout each sensory system, from the peripheral receptors to the cerebral cortex, information about physical stimuli is transformed in stages according to computational rules that reflect the functional properties of the neurons and their interconnections at each stage. (MACK, 2013, p. 497)

Upon arriving at the visual cortex, the visual information is decoded by layers of cell (figure 36). There are two types of cell decoding: sequential and parallel (figure 38). Cells working in parallel are responsible for visual motion and location analysis. The cells that work sequentially are responsible for the analysis of the form, in a gradual way, i.e., they decode the information until arriving at a form of image, which we can call the mental percept or the first moment of perception (GAZZANIGA et al., 2014) (to be seen ahead). Such arguments corroborate with Wertheimer's (1922/1938) statements from almost a century ago about brain functioning:

> The cells of an organism are parts of the whole and excitations occurring in them are thus to be viewed as part processes functionally related to whole-processes of the entire organism. (WERTHEIMER,1922/1938 apud WAGEMANS *et al*., 2012, p.15).

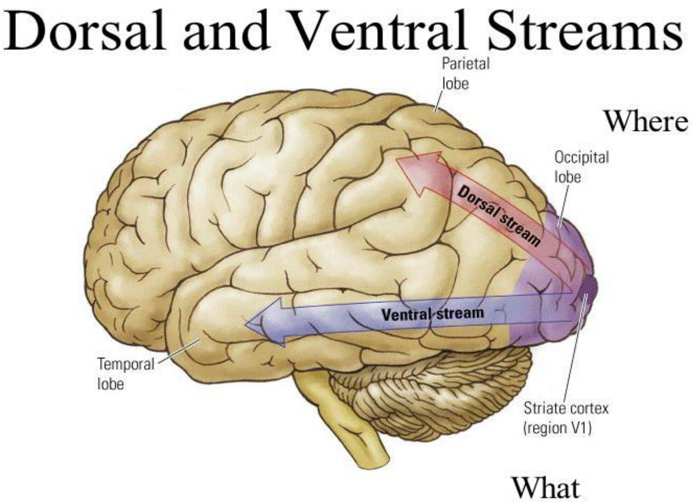


Figure 38. The visual information that is captured by the eyes is processed in two pathways, one is the dorsal (parallel) stream and the other the ventral (sequential) stream (COX, 2018), so called geographically in anatomical terms (BANICH and COMPTON, 2018).

According to Cox (2018), the entire knowledge of the functioning of such junction of visual information decoded in these two perspectives (sequential and parallel) is still a problem for neuroscience studies. However, it is known that areas of the visual cortex communicate with each other and have different dominant behaviors depending on the circumstances. Visual information is processed simultaneously, sequentially and in parallel. Mack (2013) also states that:

> A major goal of cognitive neural science is to determine how the information that reaches the cerebral cortex by means of parallel afferent pathways is bound together to form a unified conscious perception. Indeed, one of the hopes driving cognitive neural science is that progress in understanding the binding problem will yield our first insights into the biological basis of attention and ultimately consciousness. (MACK, 2013, p.498)

The ventral stream is responsible for the identification of the objects or the form (what is seen), and the pathways in which information is decoded sequentially and interpreted. Information streams sequentially through layers, which aggregate and modify the information during its passage through these brain segmentations, finding possibilities for more and more selective features of visual information. In this way, we can verify that the representation of the form is built progressively in the visual cortex.

The same visual information detected and directed by the Lateral Geniculate Nucleus (LGN) in Thalamus to the ventral stream, which constructs the image form, is developed by the dorsal system, which is responsible for identifying the object in space and in what way one must interact with him (where and how it is seen). The areas responsible for processing the visual information in the dorsal system detect the direction of movement, speed, and direction of attention in a given space or environment. Ward (2015) also states that: "It is crucial to make a distinction between the physical properties of a stimulus and its perceived characteristics" (2015, p.233), i.e., how the physical stimuli (mental perception) and subsequent mental image are developed in working memory, for example.

Such neurophysiologic approach was based on using electrodes in the brains of animals, done by Hubel and Wiesel (1962), who presented stimuli and saw how the cells responded and characterized them. In this research, the focus of the observed phenomena occurs in the visual cortex, occipital lobe and temporal inferior lobe (figure 36), mainly in the ventral stream field (figure 37 and 38) for aspects to be reported further.

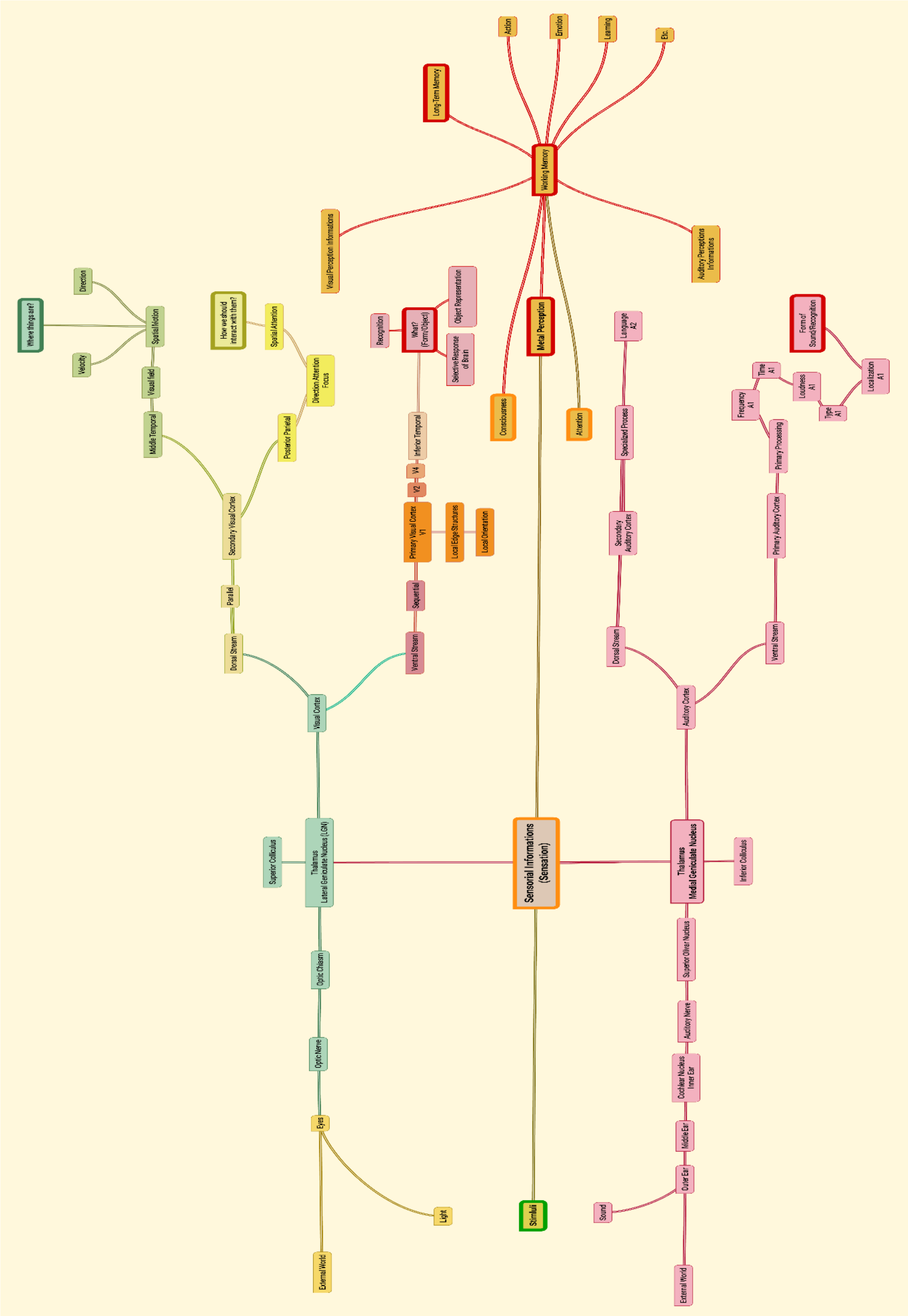


Figure 39. The path of the visual information being processed by the visual system.

3.1.2 From Visual-Sensory System to Perception

The human being interacts with the world through his perception, i.e., he interprets sensations captured by his senses (vision, hearing, smell, taste and touch) from the external world. The sensations are the result of stimuli coming from the light, in the case of visual system (the retina activates the nerve cells that interpret the light in neural electrochemical signals identifiable by brain cells). Such process is called transduction by psychophysicists: the light energy (electromagnetic radiation) of the external world turns into neural electrochemical signals in the organism. According to Sternberg & Sternberg (2012) the brain processes the visual stimuli giving them meaning and interpretation.

If sensation is the result of the stimuli decoded by the sensory system, we can presume that perception is a second moment, in which we process and construct the perceptions of these stimuli. Perception is therefore defined by the theorists as follows: “Perception is the set of processes by which we recognize, organize, and make sense of the sensation we receive from environmental stimuli” (STERNBERG; STERNBERG, 2012, p.85).

Sensation can also be approached by the types of stimuli that result in different perceptions. For example, color information, forms, or distances result in different perceptions. The focus therefore on certain qualities of stimulation leads to different perceptual processes. Above perception we can say, according to Sternberg and Sternberg (2012) that the cognitive process is the use of information obtained by perception in order to achieve certain aims.

Sternberg and Sternberg (2012) tell us that the variation of the visual stimulus is essential for the formation of visual perception. This means that the cognitive process depends on varied stimuli to act and develop on a proposition, a perceptual process. If there is no stimulus variation, a phenomenon called sensory adaptation occurs: "receptors cells adapt to constant stimulation by ceasing to fire until a change in stimulation is achieved. Through sensory adaptation, we may stop detecting the presence of a stimulus." (STERNBERG; STERNBERG, 2012, p. 89). Therefore, if the eyes adapt to the same stimulus, the variation of visual stimuli is an attribute that favors perception. Mack (2013) confirms saying about the perception that:

> Perceptions begin in receptor cells that are sensitive to one or another kind of stimulus energy. Most sensations are identified with a particular type of stimulus. Thus, light of short wavelength falling on the eye is seen as blue, and sugar on the tongue tastes sweet. How the quantitative aspects of physical stimuli correlate with the sensations they evoke is the subject of psychophysics. (MACK, 2013, p.496)

Physical stimuli need to be diversified in order to be absorbed by the sensory system to get a perception, i.e., the stimuli need to be varied in motion in order to form a mental perception or mental representation. In this way, the stimuli will be identified by the sensorial system and organized as a kind of perception. This means that the phenomenon of perception occurs only if the sensations make sense, i.e., are coherently arranged for recognition by the cognitive system. So if sensations are not organized by the perceptual system, there can be no mental representation. Hornbostel (1927) already stated that:

> What is essential in the sensuous-perceptible is not that which separates the senses from one another, but that which unites them; unites them among themselves; unites them with the entire (even with the non-sensuous) experience in ourselves; and with all the external world that there is to be experienced. (HORNBOSTEL, 1927 apud MALLGRAVE, 2010, p.88)

The creation of the mental percept in the primary sensory regions (primary cortex) develops a representation that is closely linked to the physical stimulus (GAZZANIGA et al., 2014). The perceptual experience, the mental image (not the mental percept) depends on the activity in secondary regions of cognitive association, on a high level of perception, i.e., semantics aspects (long-term memory), and not only on physical characteristics (external stimuli). One of the examples Gazzaniga and associate mention is based on the argument that the absence of a perceptual experience is matched by the absence of detectable activity in secondary regions:

> Participants were asked to decide which of two ways a stimulus was oriented (…) [figure 40]. When shown the stimulus for just a 20th of a second, people can identify its orientation with a high degree of accuracy. If, however, the stimulus is presented even faster – say, for just a 30th of a second – and it is preceded and followed by a mask of crosshatched lines, performance drops to chance levels. Nonetheless, by using a sophisticated pattern recognition algorithm on the fMRI data, the researchers were able to show that activity in V1 could distinguish which stimulus had been presented—an effect that was lost in V2 and V3. (GAZZANIGA et al., 2014, p. 198)

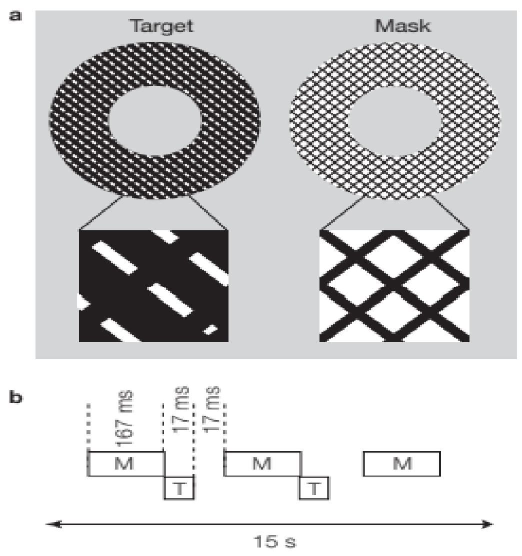


Figure 40. “Activity in V1 can predict orientation of an invisible stimulus. (a) Participants viewed an annulus in which the lines were either oriented in only one direction (target) or both directions (mask). (b) In some trials, the target was presented for only 17 ms and was preceded by the mask. On these trials, the target was not visible to the participant. A pattern classifier was used to predict from the fMRI data if the target was oriented to the left or right. When the stimulus was visible, the classifier was very accurate when using data from V1, V2, or V3. When the stimulus was invisible due to the mask, the classifier only achieved above chance performance for the data from V1.” (GAZZANIGA et al., 2014, p. 199)

Such type of experience shows us that the image to be interpreted or assimilated to something, needs to be processed in other regions of the brain (high level of cognition), beyond the mental percept detected in the primary cortex regions of the physical stimulus processing (V1).

The processes of perception recognition of the form/object (ventral pathways – primary cortex) can be considered as without high degrees of cognition, e.g., emotional attributions. As well in musical reading process: we can recognize patterns (musical figures or mental percept) in the score with no emotions, for example, if the forms that we see are developed in the primary cortex.

From the exposed above, it can be inferred that we have three basic processes for visual perceptual cognition: low level, intermediate level, and high level (figure 40):

Basic Process of Perception

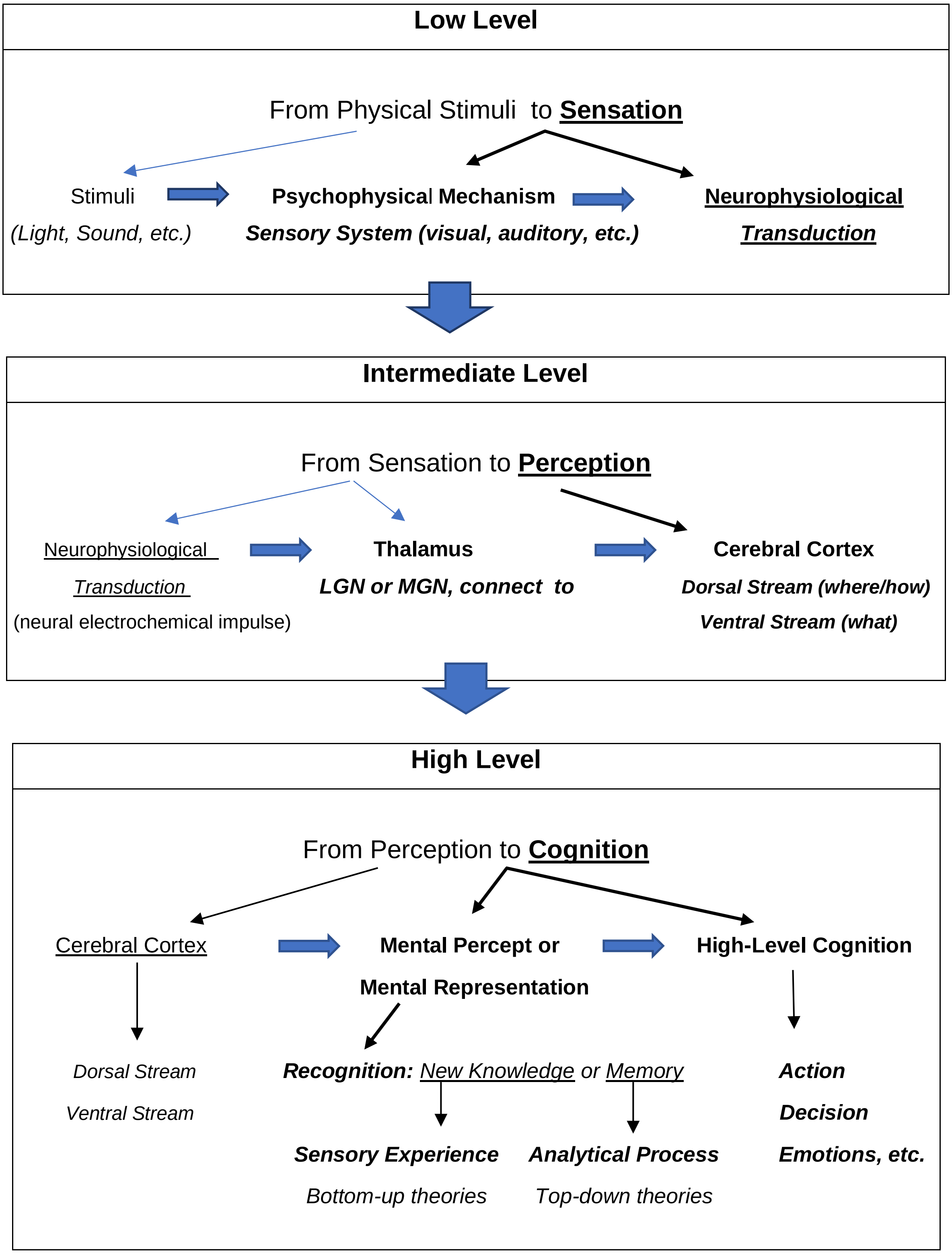


Figure 41. Visual perceptual cognition: low level, intermediate level, and high level). (WAGENMAN, 2019; STERNBERG; STERNBERG, 2012; ELMES et al., 2009; GOLDSTEIN, 2011; MATLIN, 2013.)

3.2 Auditory System

3.2.1 Psychophysics Aspects

The knowledge that neuroscience has about the functioning of the auditory cortex is not yet in equivalence with the knowledge that it has of the visual cortex (COX, 2018). However, it is known that there are many similarities. The auditory system catches sound waves, just as the visual system catches the light.

Sound waves are the result of the pressure of molecules (air, water, etc.) caused by some type of material and propagated by vibrations in time and space. After the sound waves are received by the ears and absorbed by the auditory system, they are encoded in neural electrochemical signals in the inner ear by means of the transduction of the neurons responsible for the sound waves encoding (figure 42).

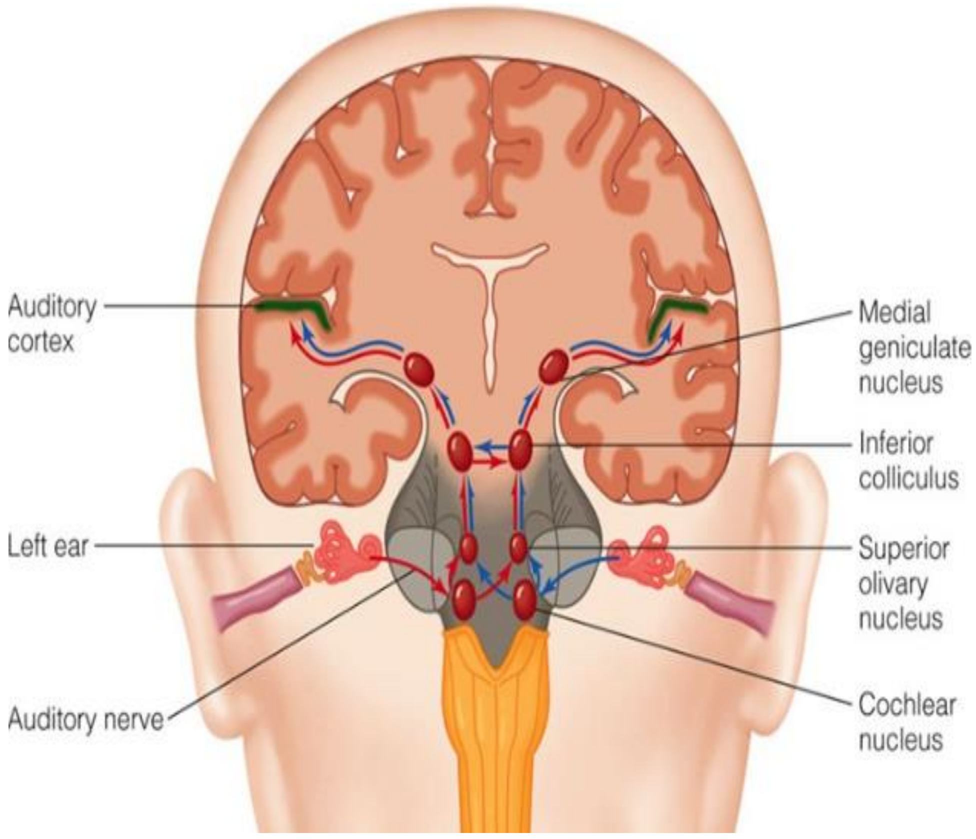


Figure 42. The ears receive sound waves, and transmitted through the auditory system by transduction; the neural electrochemical signals is sent to the auditory cortex (SHARMA, 2020).

The neural electrochemical signals are taken to the Medial Geniculate Nucleus (MGN) in Thalamus responsible for the distribution of sound information, being sent to the auditory cortex to be finally analyzed and decoded. The auditory cortex is composed of several layers of cells, each one being responsible for the perception of specific sound characteristics (figure 43).

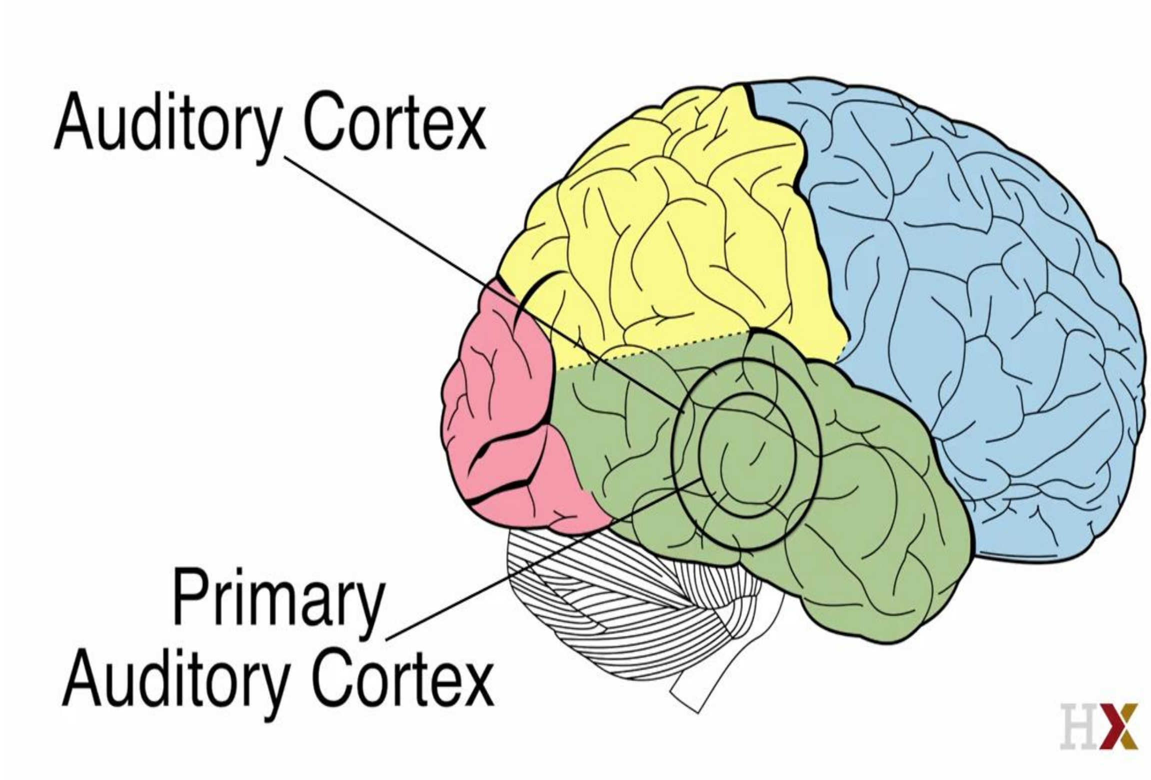


Figure 43. Green field corresponds to the temporal lobe – auditory cortex. Red field to the occipital lobe. Blue field to the frontal lobe. Yellow field to the parietal lobe. The auditory cortex is responsible for the analysis and conscious perception of sound. The conscious perception of sound still requires research to be precisely defined by neuroscience (COX, 2018).

The primary cortex (A1) is responsible for the analysis of frequency, time, intensity, type and localization. The secondary cortex (A2) is responsible for language and phonemes, for example (figure 44). The thalamus is also responsible for directing information about sound attention (COX, 2018).

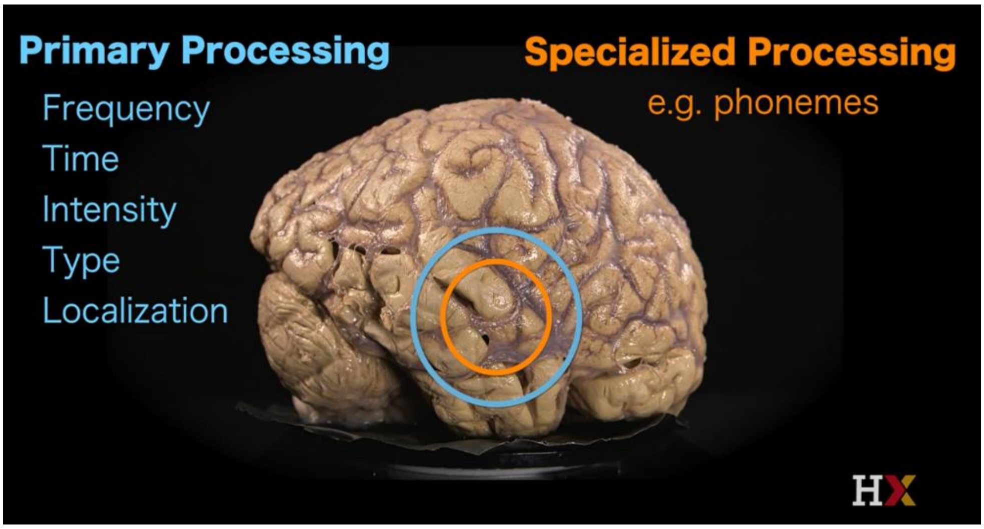


Figure 44. At first, in the primary cortex of the auditory system, information received by the thalamus is decoded in frequency, time, intensity, type and location. In the secondary cortex specialized information is decoded, such as phonemes (COX, 2018).

The auditory cortex, as well as the visual cortex, processes the perception of sound through cell layers (figure 45). However, the processing of the acoustic image is not limited only to the field of the auditory cortex. It is spread in both hemispheres of the brain, and in other brain regions. If the auditory system undergoes any type of lesions, the hearing will be not completely lost, because the cells responsible for the auditory perception are spread in several brain regions.

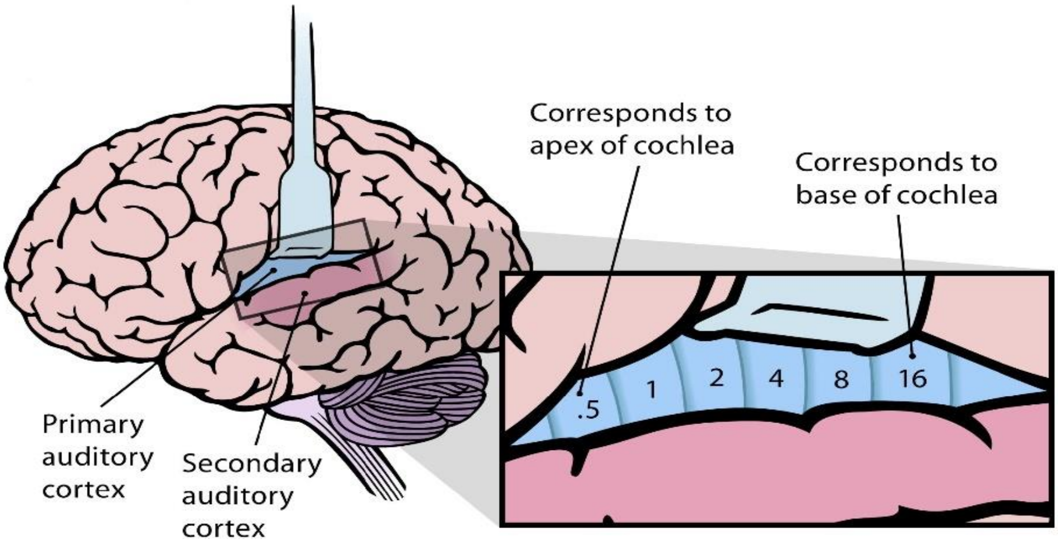


Figure 45. “Lateral view of the human brain, with the auditory cortex exposed. The primary auditory cortex contains a topographic map of the cochlear frequency spectrum (shown in kilohertz).” (CHITTKA and BROCKMANN, 2005)

Similar to the visual system, the auditory system is divided into two functions, i.e., the sensory information is distributed in ventral (what) and dorsal (where and how) pathways. "The posterior belt [parietal lobes] is involved in localizing sounds, and the anterior belt [temporal lobes] is involved in perceiving complex sounds and patterns of sounds" (STEINBERG; STEINBERG, 2012, p. 298). Baker (2016) writes that:

> Like the visual system, the auditory system also has identifiable 'what' and 'where' pathways […], which process the location of sound in parallel to recognizing its meaning. For the visual system, recognizing an object automatically implies working out where it is, while for audition it is possible to recognize a sound without being aware of its precise location. (BAKER, 2016, p.76)

About auditory cortex research, Sternberg and Sternberg (2012) emphasize that by the 1950s, experiences in this field focused on the function of the large area of the auditory cortex. Because experiments focused only on the large auditory cortex area are very complex, such kind of experiment is being avoided. Recently the researches of the auditory system concentrate in smaller areas of the cortex, that is, areas beyond the temporal lobe, expanding to other areas of the cerebral cortex. As said above, the auditory perceptual system is distributed in many ways in the human brain.

3.2.2 Psychophysical Aspects of Music

According to psychophysical aspects, i.e., the relationship between the external stimulus and its reception in the human sensory system, Loveday (2016) states that:

> Our world consists of an infinite array of sounds but they are characterized by three basic elements: pitch, loudness and timbre. Pitch is what a musician might call the 'note' (e.g. middle C or F sharp) and this is essentially how high or low it sounds. The pitch is determined by the frequency of the air vibrations, so the voice of a screaming child will cause very fast vibrations of air molecules (i.e. high frequency), and the deep rumble of thunder will cause very slow vibrations (i.e. low frequency).
>
> Loudness, as the name suggests, describes how loud a sound is and is determined by how big the vibrations of air molecules are. So a scream will cause bigger vibrations than a flute, for example, and therefore have a louder volume. The timbre of a sound is essentially the tonal quality that enables us to

> identify it, so for example a flute has a very different sound from an electric guitar even when they are playing the same note. The reason that different instruments and different voices have different timbres is because of additional 'harmonic' vibrations that occur when the sound is produced (…) (LOVEDAY, 2016, p. 309)

The grouping of such elements (pitch, loudness, and timbre) in time and space generates: the melody (sequence of notes), the rhythm (beat, meter, etc.) and harmony (overlap of sounds based on durations). These "three elements – melody, harmony and rhythm – form the basis of music and give rise to a sense of meaning and emotional character" (LOVEDAY, 2016, p.312), the organizational foundation of western tonal music.

The figure 46 demonstrates musical perception in a bottom-up approach, but it should be noted that the top-down process completes the cognitive musical perception.

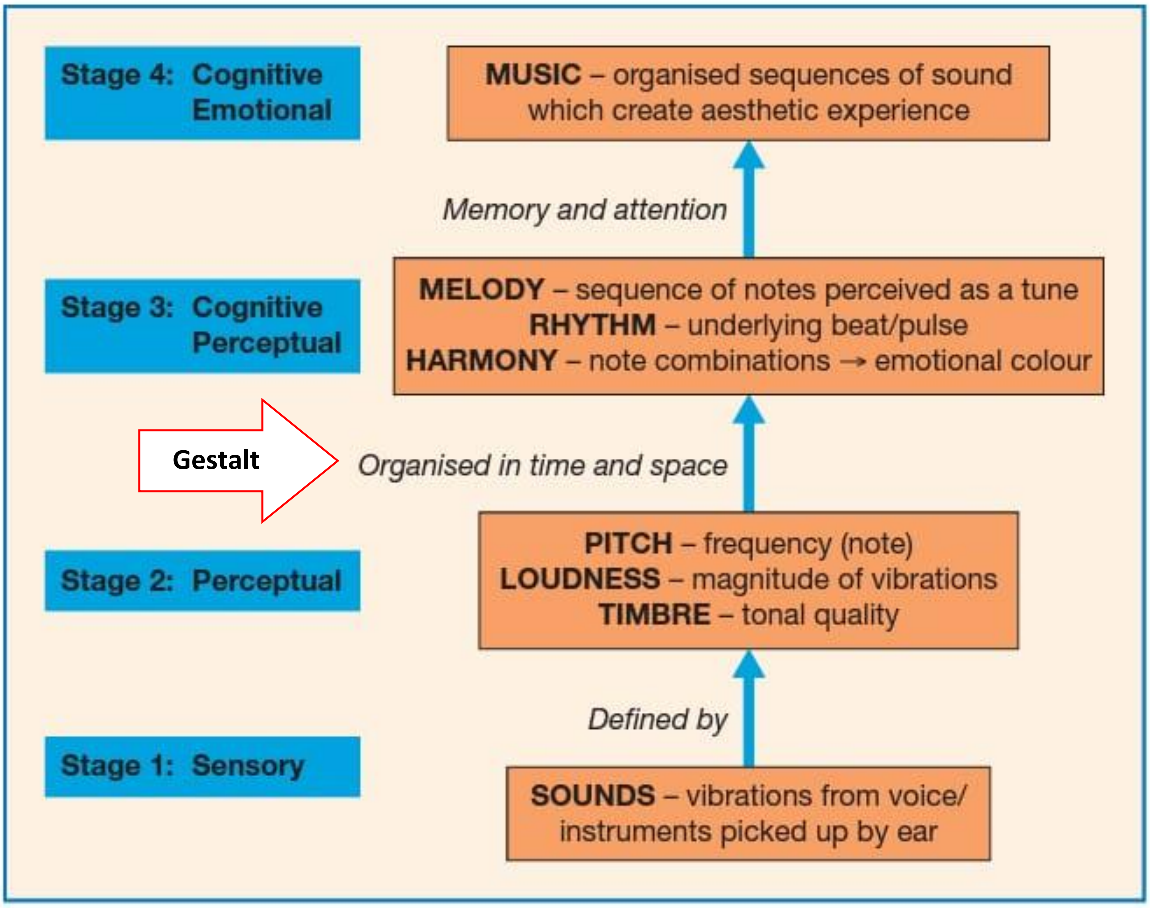


Figure 46. Stages approach bottom-up in music perception. White arrow for the organization of music for adapted. (LOVEDAY, 2016, p. 308)

3.2.3 Perceptive Process Aspects of Music

The basic process of the auditory perception system is structured in the same way as the process of perception of the visual system. Loveday (2016) states that:

> In the first sensory step, the ear collects the sounds around us and the auditory nerve carries information about the pitch, loudness and timbre of sounds to the auditory cortex. (LOVEDAY, 2016, p. 309)

Therefore, the ears receive an external physical stimulus that goes through the process of transduction in the human auditory system and then forms a mental percept that will be cognitively interpreted. Baker (2016) states that:

> The perception of sound ultimately involves cognitive processing, and this implies that we need to adopt a cognitive approach in which sensor information processing happens along with symbolic information processing to produce a perception. (BAKER, 2016, p.75)

According to Cox (2018), the basic elements of sound are recognized by the primary auditory cortex, that is: frequency, time, intensity, type and localization. And Loveday (2016) states that we can categorize sound, i.e., recognize the perceptual organization of sensory information (stimulus) such as speech, noise, or music. We will focus on the musical aspects, i.e., how we process musical information and make sense of such information.

According to Ward (2015), there are two approaches in which music can be studied: music perception and music production. In these assumptions we can observe characteristics of sound sensory information for pitch organization, temporal organization and meter, that is.:

> (…) a distinction between pitch organization (which includes pitch relations between notes) and temporal organization, including rhythm (the tempo of beats) and meter (the way beats are grouped). (WARD, 2015, p. 244)

In this way, music is described as the organization of sounds (GOLDSTEIN, 2015; LOVEDAY, 2016). Ward (2015) comments that the Western musical system when perceived by the brain, organizes the sensory information at pitch levels, and perceptible form of groups and patterns, depending on the physical relationships between the musical notes. Janata el al. (2002) also state that:

> Western tonal music relies on a formal geometric structure that determines distance relationships within a harmonic or tonal space. In functional magnetic resonance imaging experiments, we identified an area in rostromedial prefrontal cortex that tracks activation in tonal space. Different voxels [i.e. three-dimensional pixels] in this area exhibited selectivity for different keys. Within the same set of consistently activated voxels, the topography of tonal selectivity rearranged itself across scanning sessions. The tonality structure was thus maintained as a dynamic topography in a cortical area known to be at a nexus of cognitive, affective, and mnemonic processing [….]. What changed between sessions was not the tonality-tracking behavior of these brain areas but rather the region of tonal space (keys) to which they were sensitive. This type of relative representation provides a mechanism by which pieces of music can be transposed from key to key, yet retain their internal pitch relationships and tonal coherence […]. (JANATA et al., 2002 apud RAFFMAN, 2011, p. 596)

According to Raffman (2011), the activation patterns in the cortex corresponds to the relationships among tonal keys, i.e., “each key (C major, C minor, D major, etc.) activates a unique assembly of neurons in the frontal cortex in a given hearing." (RAFFMAN, 2011, p. 595). In another perspective, it was found that when listening to the same music or different music, such arrangement can be activated by a different key, but the relationships between the keys are preserved (RAFFMAN, 2011).

In the Western tradition, note sequences are organized vertically and horizontally through musical notation, representing the organized description of the physical motion of sound. Raffman (2011) states that:

> The scientists’ thought is that the tonal pitch relationships in a musical work are isomorphic to, and hence can be theoretically modeled and psychologically represented as, certain spatial relationships. [...] It is hardly coincidental that music theorists use the term “progressions” to refer to transitions among harmonies, or that they characterize fast (slow) changes of harmony as fast (slow) harmonic motion. For another thing, musical motion may be a kind of apparent motion, rather like the apparent motion we experience when looking at a row of lights that flash serially in quick succession. Nothing moves; rather, it appears as if something (a light?) moves. (RAFFMAN, 2011, p. 598-599)

Deutsch (1982) states that the visual stimulus (music notation) is in perceptual equivalence to the auditory stimulus (sound) for the perceptual organization of music. We can infer an intrinsic compatibility between the sound mental perception and the visual mental perception of music.

3.3 Visual and Auditory Perception

When we talk about the interaction of sensory systems, it is necessary to resort to many fields of approach and research besides the exclusive approach of the visual system or the auditory system. For the sake of brevity, however, we will make some considerations of the multisensory research, focused only on the visual and auditory systems. Banich and Compton (2018) write that:

> Both the auditory and visual systems must extract meaningful information from a massive amount of ever-changing input, whether it be patterns of light or sound waves. […] both sensory systems tackle these problems through a combination of serial processing, in which information ascends through a hierarchy of successive stages, and parallel processing, in which different processing streams are specialized to handle different aspects of the sensory stimulus. The representation of light and sound patterns (along with other sensory information such as smell, touch, and taste) allows us to understand the surrounding environment and forms the essential raw materials for other processes such as memory and language. (BANICH; COMPTON, 2018, p.164)

Firstly, it should be remembered that the processing of the sensory and perceptual systems of the visual and auditory perception are similar. Both receive in the Thalamus (located in the center of the brain) the neural electrochemical signals of the sensorial systems receivers by means of the transduction. In Thalamus, the anatomical region responsible for the auditory system, is located in the Medial Geniculate Nucleus (MGN), from where fibers send the received stimuli to the Primary Auditory Cortex of Temporal Lobe. The region responsible for the visual system is in the Lateral Geniculate Nucleus (LGN) from where fibers send the received stimuli to the Primary Visual Cortex.

The sensory information is organized and mapped physiologically in the auditory system by sound frequency and in the visual system by position in the retina. The organization of information in cerebral cortex corresponds, ordinarily, to the same organization in the Thalamus and when it is being received by sensory systems.

The auditory system tends to assimilate perception over time, and the visual system tends to assimilate information through space. Therefore, the auditory stimulus requires a more complex research than the visual one. In both, auditory and visual systems, the processing of the data is analyzed in the cerebral cortex by ventral and dorsal pathways, that is, the ventral pathways decode "what" is the sensory stimulus (V1 and A1) and the dorsal pathways decode "where / how" is it (V2 and A2) (figure 47).

COMPARISONS BETWEEN THE AUDITORY AND VISUAL SYSTEMS

	Auditory system	Visual system
Thalamocortical route	Medial geniculate nucleus projects to primary auditory cortex	Lateral geniculate nucleus projects to primary visual cortex
Organizing principle of early neural processing	Tonotopic organization (orderly mapping between sound frequency and position on cortex)	Retinotopic organization (orderly mapping between position on retina and position on cortex)
Temporal and spatial sensitivity	Temporal > Spatial	Spatial > Temporal
Functional specialization of feature processing	Less well documented in the auditory domain	Well documented for color and movement
Higher-order context-dependent pathways	Evidence for separate auditory pathways for “what” versus “where”/“how”	Evidence for separate visual pathways for “what” versus “where”/“how”

Figure 47. Auditory and visual system (WARD, 2015, p.237)

According to Banich and Compton (2018) “there is still much to be learned about how the sensory modalities interact, it now seems clear that there are several possible mechanisms for their interaction” (p. 164) (see figures 48 and 49).

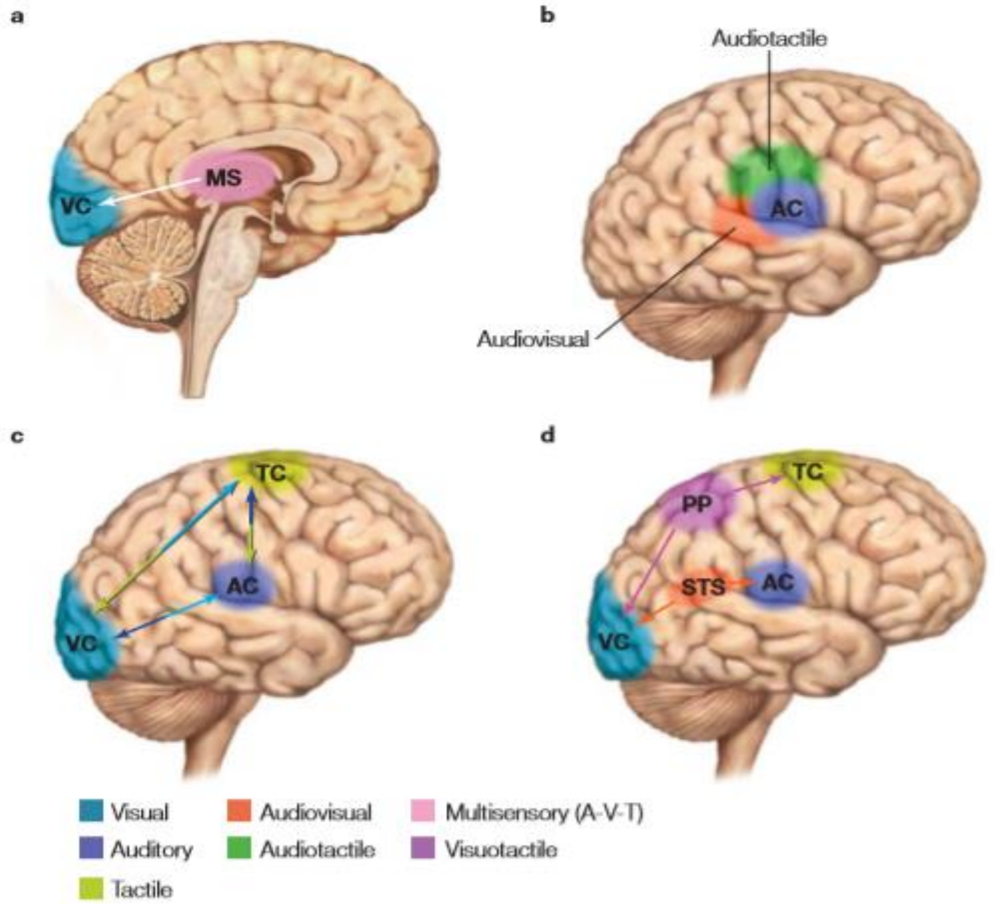


FIGURE 5.48 Various schemes of multisensory interaction.
(a) Multisensory integration occurs subcortically (e.g., thalamus). Input to cortical areas is already influenced by information from other sensory modalities. **(b)** Modality specific regions are surrounded by multisensory regions that receive input from other modalities. **(c)** Multisensory interactions occur through communication between modality specific regions. **(d)** Certain cortical areas are specialized for multisensory processing. PP = posterior parietal cortex; STS = superior temporal sulcus.

Figure 48 Hypotheses of multisensory studies in the human cerebral cortex. All presented hypotheses are considered by scientific researches. VC – Visual Cortex, MS – Multisensory Sense, AC – Auditory Cortex, TC – Tactile Cortex, PP – Posterior Parietal Cortex, STS – Superior Temporal Sulcus. (GAZZANIGA et al., 2014, p.212)

Research about the interaction of the visual and auditory system, focused on visual influences on auditory processing, points that “cells in auditory cortex are influenced by visual information” (BANICH; COMPTON, 2018, p. 436) still in the primary cortex (A1), responsible for the recognition of patterns. Such discovery changes the idea that the processing of perception occurs only by association in cognitive processes in high-level domain, bringing a new insight that our process of multisensory perception can also occur by modulation (figure 48c), not just by association (figure 48b) (GAZZANIGA et al., 2014).

> An example of multisensory processing in auditory cortex comes from a study that examined responsiveness to vocalizations in monkeys (Ghazanfar et al., 2005). Researchers recorded signals from populations of cells in the core and belt regions of monkey auditory cortex while the monkey either heard the sound of another monkey's grunt, viewed a silent video of the other monkey making the grunt sound, or heard the grunt together with the video. Not surprisingly, the sound without video activated cells in the auditory cortex, whereas the video without any sound did not activate auditory cortex cells. Most interestingly, though, the response of auditory cortex cells to the sound was altered by the simultaneous presence of the video. Some cell populations showed an enhanced response when the grunt sound was accompanied by the video, and others showed a suppressed response. (BANICH and COMPTON, 2018, p. 436)

Gazzaniga et al. (2014) state that in old perception studies, the visual system prevailed over the other senses. Today, we believe in a process of integrated senses in the cognitive perception of sensory information. It can be affirmed that:

> In this view, visual capture occurs because the brain judges visual information in most circumstances to be the most reliable and thus, gives it the most weight. The system is flexible, however, and the context can lead to a change in how information is weighed. (GAZZANIGA et al., 2014, p.209)

Groome et al. (2014) say that the visual system interferes favorably with the accuracy of auditory information, i.e., "auditory localization performance is therefore improved if auditory stimulus is accompanied with a meaningful (congruent) visual cue" (GROOME et al., 2014, p.54).

The type of visual stimulus affects the degree of auditory improvement: “if the visual stimulus responds strongly to the auditory stimulus, participants will perform more accurately” (GROOME et al., 2014, p.54). It can be concluded that the visual sensory information (stimulus) can interfere in the auditory sensory formation (figure 48a), and consequently influence the formation of the mental perception (mental representation). Baker (2016) points out that:

> For humans at least, the auditory system may function in the *service* of the visual system when we need to locate something. The visual system often takes priority when we need to work out where something is, with hearing only providing supplementary information. (BAKER, 2016, p.76).

Gazzaniga et al. (2014) also explain that somewhat earlier than these more recent discoveries of multisensory processing in the cerebral cortex, the "[…] multisensory processing has spawned several hypotheses about the pathways and connections between the processing areas and the resulting way that the processing occurs." (GAZZANIGA et al., 2014, p.211).

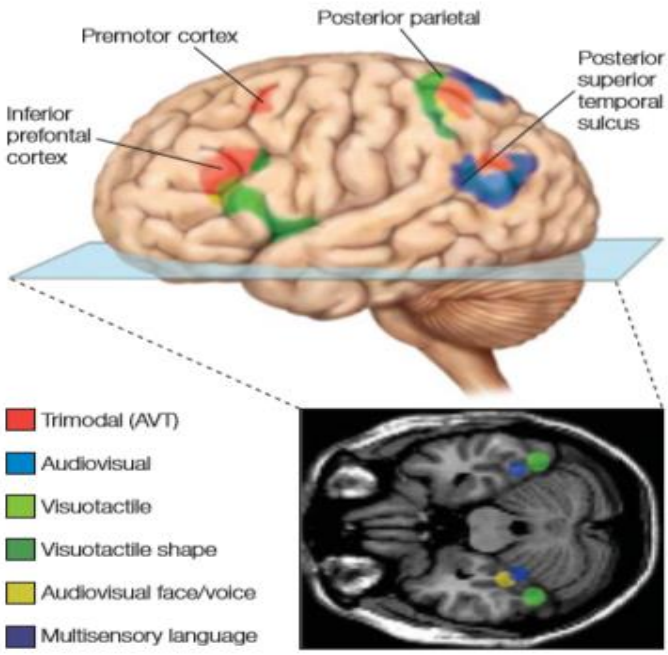


Figure 49. Regions of multisensory neurons (GAZZANIGA et al., 2014, p.210).

In this research, then, we will consider the perspective that the visual sensory information (stimulus) can interfere in the auditory sensory information (figure 48a), and consequently influence the formation of the mental perception (the mental representation). We will consider that the type of visual stimulus affects the degree of auditory accuracy, conscious that the process of integrating senses into the cognitive perception of sensory information could have different hypotheses, and that the system flexibility can provoke changes in information evaluation (GAZZANIGA et al., 2014).

The correspondence (or integration) of visual and auditory stimuli is verified by multisensory (audiovisual) cells (figure 49). The correspondence is also verified in the accuracy of mental perception in multisensory processing (figure 48). Considering music perception as a symbolic information, it is necessary that the stimuli are decoded in different brain regions. Science knows, to this day, that it is the primary cortex specialization that stands for object decoding (recognition), i.e., in the primary auditory cortex, the sound object is identified in: frequency, time, volume, type, location, etc.

The correspondence of visual and auditory stimuli as recognition of a audiovisual object can be mediated, according to Deutsch (1982), by the Gestalt principles (see below). Sternberg and Sternberg (2012) state that "people tend to use Gestalt principles even when they are confronted with novel stimuli" (p.115).

No prior knowledge is required to perceive a sound, visual or audiovisual object. We can, for example, visualize an individual in a quiet room, where a slide with three squares is presented, while listening to three knocks on the door. The semantic processing (high level, or top-down of the secondary cortex) of such situation would be a second moment. The processing of mental percept, verified in the primary cortex, in the identification of the object (sound and visual), would be a case of similarity.

Deutsch (1982) states that there is an equivalence between visual stimulus and auditory stimulus for the perception of musical organization, and this equivalence is disposed in levels or types of abstraction. According to her, we can use the Gestalt Theory (especially applied to sound grouping) in this first level of abstraction to classify the perception of music.

Therefore, due to the processing of the external stimulus being first decoded by the form or object in the primary cortex, we will mention below the principles of Gestalt Theory, which correspond to the moment of the perceptual organization of these objects and forms.

3.4 Perceptual Organization of Objects and Form – Gestalt Theory

One of the attributes of human perception is the ability to organize sensory stimuli (low level), and to develop them in more complex cognitive processes (high level). One approach that explains such human capacity is the Gestalt Theory, based on psychophysical experiments by Max Wertheimer from 1912.

The word *Gestalt* means configuration, form, in German, and carry the idea of the theory itself, the theory of form under the point of view of its psychophysical aspects. Wertheimer (1912) ratified his research primarily as an organizational perception of visual objects and complemented his research in 1923 conceiving coherent perceptual groups in field of visual perception (which will be seen ahead).

The human being has great sensory and cognitive capacity. However, this capacity of information processing converges to a single thought, which we can call consciousness. Formerly, researchers believed that attention and consciousness were the same. It is now recognized that the active processing of sensory attention and its previous active process of information (memory) does not have to be linked to consciousness (STERNBERG; STENRBERG, 2012). In order to occur such cognitive process, the perception has to organize the sensory data in a coherent way, carrying them to attention and consciousness.

Researches on Gestalt Theory present evidence that brain activity uses mechanisms of sensory organization, including a multisensory approach: "[...] the object perceived along with features presented with these stimuli in other modalities (e.g., sounds) are bound together in the occipital-temporal cortex of the brain" (MCBRIDE; CUTTING, 2019, p.106). The same authors also present other studies and point that:

> Pomerantz and Portillo (2012) describe research that supports use of the organizing principles from the Gestalt approach in perception. Such studies have shown that larger arrays of stimuli containing basic feature elements and more complex stimuli are easier to perceive than smaller basic arrays and stimuli shown to subjects. This is called the configural superiority effect. (MCBRIDE; CUTTING, 2019, p.105)

We can also observe that the principles of Gestalt Theory were initially investigated in the visual sensory system, but were transposed and adapted to other sensory systems, such as hearing (BAKER, 2016; DEUTSCH, 2013). Therefore, the perceptual equivalence of the Gestalt Theory can be used in an integrated manner (audiovisual).

It is worth note that, in the case of people with musical instruction, visual objects (musical notation) are interconnected with the perception of auditory sensorial stimuli (GOLDSTEIN, 2015; WARD, 2015). Loveday (2016) affirms the relevance of Gestalt Theory for music because its nature is basically formulated from the organization of sounds, saying that: "these principles of perceptual grouping play an important role in how music is composed, performed or produced." (p.310)

3.4.1 Principle of Perceptual Organization to Visual System

The first theoreticians of the Gestalt Theory, like Max Wertheimer, Kurt Koffka, and Wolfgang Köhler, considered a Gestalt “as a whole in itself, not founded on any more elementary object," and that “perception was not the product of sensations but it arose through dynamic physical processes in the brain” (WAGEMANS, 2012). Sternberg and Sternberg (2012) mention that: “people tend to use Gestalt principles even when they are confronted with novel stimuli.” (p.115)

According to the Gestalt Theory, we have some laws or neural configurations, that automatically condition the organization of our perception. The individual observes a part that tends to restore the overall understanding of a whole, the balance of form. This means that our perceptual organization is categorized into patterns in the perceptual processing of sensory stimuli.

Gestalt Principles	Principle	Figure Illustrating the Principle
Figure-ground	When perceiving a visual field, some objects (figures) seem prominent, and other aspects of the field recede into the background (ground).	Figure 50 shows a figure-ground vase, in which one way of perceiving the figures brings one perspective or object to the fore, and another way of perceiving the figures brings a different object or perspective to the fore and relegates the former foreground to the background.
Proximity	When we perceive an assortment of objects, we tend to see objects that are close to each other as forming a group.	In Figure 51 (a), we tend to see the middle four circles as two pairs of circles.
Similarity	We tend to group objects on the basis of their similarity.	In Figure 51 (b), we tend to see four columns of xs and os, not four rows of alternating letters.
Continuity	We tend to perceive smoothly flowing or continuous forms rather than disrupted or discontinuous ones.	In Figure 51 (c), we tend to perceive smoothly flowing or continuous forms rather than disrupted or discontinuous ones.
Closure	We tend to perceptually close up, or complete, objects that are not, in fact, complete.	Figure 51 (d) shows only disjointed, jumbled line segments, which you close up to see a triangle and a circle.
Symmetry	We tend to perceive objects as forming mirror images about their center.	For example, when viewing Figure 51 (e), a configuration of assorted brackets, we see the assortment as forming four sets of brackets, rather than eight individual items, because we integrate the symmetrical elements into coherent objects.
Prägnanz	We tend to perceive any given visual array in a way that most simply organizes the different elements into a stable and coherent form.	For example, we tend to perceive a focal figure and other sensations as forming a background for the figure on which we focus.

*Table 1. Gestalt Principles of Visual Perception. The Gestalt principles of Prägnanz, proximity, similarity, continuity, closure, and symmetry aid in our perception of forms. (*STERNBERG AND STERNBERG, 2012, p. 113-115)

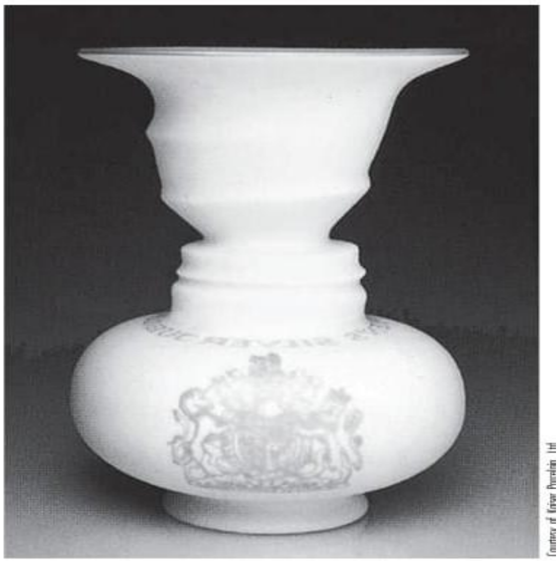


Figure 50. Principle of the figure-ground effect.

(STEINBERG; SETEINBERG, 2012, p.114)

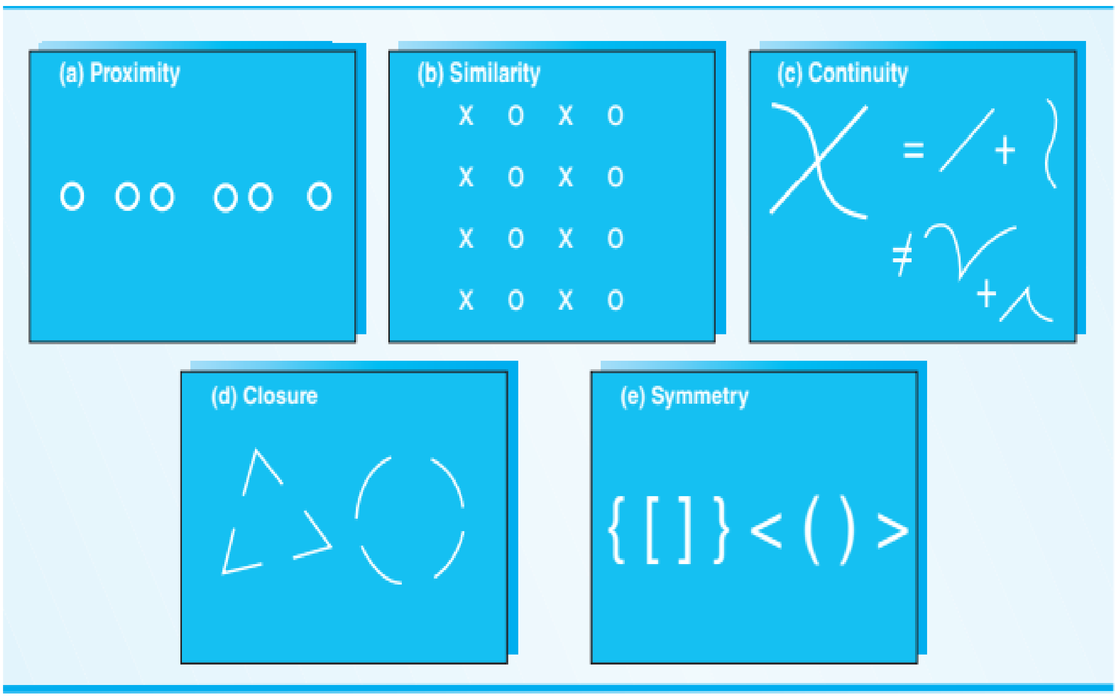


Figure 3.18 The Gestalt Principles of Form Perception.

The Gestalt principles of form perception include perception of figure-ground, (a) proximity, (b) similarity, (c) continuity, (d) closure, and (e) symmetry. Each principle demonstrates the fundamental law of law of Prägnanz, which suggests that through perception, we unify disparate visual stimuli into a coherent and stable whole.

Figure 51. The Gestalt Laws. (STEINBERG; SETEINBERG, 2012, p.113)

The perceptual organization in Gestalt Theory is categorized by patterns. Figure-ground: the perception of an object depends on a relationship between the emergent figure (object) and the background (ground), i.e., perception changes depending on the focus of attention (figure or ground); proximity is a law of perceptual organization which says that the brain automatically groups any visual objects with close relation in space; similarity: the visual cortex groups objects with similar aspects; continuity: the brain tends to understand as continuous form figures even if these are somehow interrupted; closing law tends to complete images in order they can be cognitively processed; symmetry causes the perception of groups objects in conformity with other groups (see table 1). Sternberg and Sternberg (2012) described Gestalt Theory empirically in following terms:

> We see groupings of nearby objects (proximity) or of like objects (similarity). We also perceive objects as complete even though we may only see a part of them (closure), continuous lines rather than broken ones (continuity), and symmetrical patterns rather than asymmetrical ones. (STERNBERG; STERNBERG, 2012, p.114)

Finally, the principle of Prägnanz suggests that all perception is unified in a single stimulus, with maximal level of stability and simplicity. Wagemans (2012) writes:

> The most general principle was the so-called law of Prägnanz, stating, in its most general sense, that the perceptual field and objects within it will take on the simplest and most encompassing (“ausgezeichnet”) structure permitted by the given conditions. (WAGEMANS, 2012)

Such grouping principles were conceived by Wertheimer (2012), and developed further by other researchers, like Kurt Koffka (1936) and Wolfgang Köhler (1947). Other principles have been developed more recently by other researchers, other types of Gestalt, on aspects of cognitive interaction at high levels such as memory and association, for example.

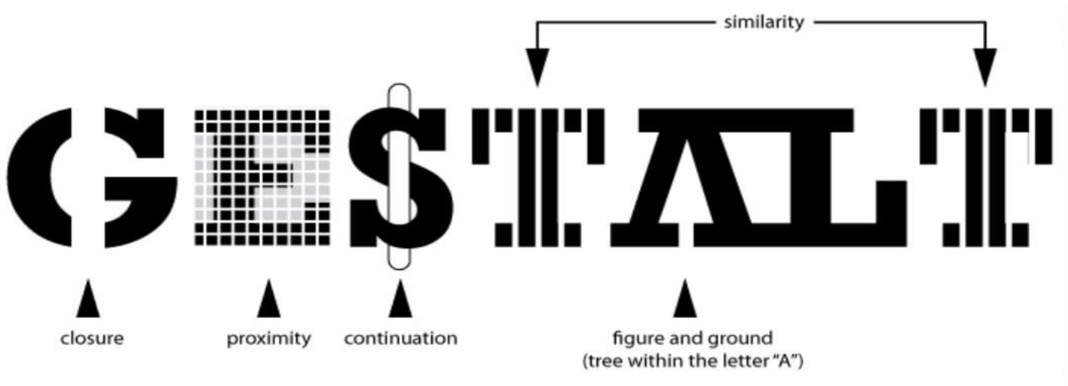


Figure 52. Principles of Gestalt Theory found through Wertheimer's (1923) (SZAMEITAT, 2017, p.29).

3.4.2 Principle of Perceptual Organization in Music

In the cognitive musicology, the Gestalt Theory approach is applied to the research on cognitive processes related to music (LEMAN, 1997). Deustch (1982) states that by listening to music, we need to identify and recognize patterns of sounds, i.e., we group the stimuli into principles of the Gestalt Theory of "proximity – sounds that seem to be close together in space – and similarity – sounds that seem close to pitch, timbre or loudness" (LOVEDAY, 2016, p.310). Baker (2016) also comments that the "Gestalt principle of 'continuation' has often been researched in auditory perception because there is neurological evidence that the auditory cortex makes predictions about sequences of sounds." (BAKER, 2016, p.78)

Therefore, in music, the Gestalt Theory is widely used for research (DEUTSCH, 2013b; MESQUITA, 2016; MEYER, 1956; SHEPARD, 1999). According to Baker (2016) "Separating out sound into perceptual 'figure and ground', first described by the Gestalt psychologists, is as important in auditory perception as it is in visual perception." (BAKER, 2016, p. 76).

An example of Gestalt Theory approach to music complemented with aesthetic experience can be found in Meyer's book (1956). Its title already addresses a perspective on high-level cognition: "Emotion and Meaning in Music". Raffman (2011) states that:

> A further significant line of scientific research grew out of the work of music theorist Leonard Meyer (1956), often credited as the first theorist to take account of psychological research. (…) Meyer argued that understanding a piece of music involves having certain "undifferentiated feelings" of tension and release in response to it (1956: 18). General features of human perceptual psychology (e.g. Gestalt principles of grouping and continuation), together with our knowledge of tonal structure and musical style, engender certain (musical) expectations in us when we listen to music. When our expectations are either violated or fulfilled, we experience a feeling of tension or release, respectively. (RAFFMAN, 2011, p. 594)

Meyer (1956) uses Gestalt Theory applied to perceptual process beyond high level cognitive processes, for example, involving emotion and long-term memory. Meyer (1956) point, for example, that

> Without thought and memory there could be no musical experience. Because they are the foundation for expectation, an understanding of way in which thought and memory operate throws light both upon the mechanism of expectation itself and upon the relation of prior experience to expectation. (…) As we listen to a particular musical work we organize our experience and hence our expectations both in terms of past of that particular work, which begins after the stimulus has been heard and consequently "past", and in terms of our memories of earlier relevant musical experiences. (MEYER, 1956, p.88-89)

Leman (2008) argue that the Berlin School for Gestalt Theory established at the beginning of the 20th century by Max Wertheimer, Wolfgang Köhler and Kurt Koffka has developed a solid basis for the development of music research in another cognitive paradigm. Wagemans (2012) point that the paradigm of the Berlin School for Gestalt Theory is the psychophysical stimulus (low level). And Shepard (1999) points that the "(…) brain has been shaped by natural selection; only those organisms that were able to interpret correctly what goes on in the external world and to behave accordingly have survived to reproduce." (SHEPARD, 1999, p.21-22)

The Gestalt Theory approach is an important tool for the organizational perception of music. Both in psychophysical aspects (low level), as well as in high level process approaches such as emotions, memory, etc. In our research, we first examined the visual stimulus (and the auditory stimulus), which after being decoded in the primary cortex, is neurally organized into Gestalts (the mental perception) for later semantic interpretation.

3.5 Considerations

We conclude that the perceptual process of cognitive formation occurs after the arrival of sensory information in the cerebral cortex, at a moment of recognition of the object and in a moment of association with more advanced cognitive processes.

In next chapter we will examine the moment of the recognition of the object, i.e., through the perceptual organization of the visual objects in the music score and understand the process of perception of the musical construction of selected musical excerpts. The basis of the research are audiovisual aspects of pedal harp score reading. Such procedure is a feature of the decoding in the primary cortex process.

It is scientifically established that the brain responds to psychophysical stimuli in the primary sensory cortex (V1 and A1). And that more sophisticated processes are elaborated in the associative cortex. This involves other processes of cognition, besides the recognition of physical stimulus (the mental percept), such as memory, emotions, attention, and consciousness, for example.

Previously pointed out by neuroscientists and recently examined in cerebral neurophysiology, we can see the difference between the low level approach and high level approach for organizational perception with the help of the Gestalt Theory. We will use the perspective of Gestalt Theory of the Berlin School for visual perceptual organization (sensory psychophysical aspects) in low level approach. Sensory experiences come from visual stimuli of the music score. Such experiences can guide us thereafter towards the construction of a visual musical perception in a high level domain, improving analytical processes, for instance.

4. PRACTICAL APPLICATION IN SELECTED REPERTOIRE

We observed, in chapter 3, how a person perceives something new, i.e., a certain object or form with which he/she never had direct contact before. The brain organizes sensory stimuli in an order that allows the information to be perceived and then developed cognitively. Such processing is part of the biological characteristics of the human brain structure for decoding objects and forms. The brain works to establish a mental representation for the perception.

In chapter 2, we approached the idiomatic configuration of musical notation for the pedal harp. We observed that to play the pedal harp we use four fingers from each hand. The intervals between the fingers are determined by the anatomical configuration of the hands. Therefore, due to the anatomical nature of hands, musical works for harp follow established patterns, something also observed in the musical notation on chords, scales, and other effects.

In this chapter we will observe forms of the mental percept, i.e., patterns and configurations established by Gestalt Theory, in selected musical works from Pierné (1901), Ravel (1905), and Villa-Lobos (1953). We will consider the approach in which the mental percept (the visual sensory configurations) does not attribute an *a priori* musical *qualis,* or auditory or visual image, but decodes the tacit and anatomical features of the musical notation.

4.1 Musical Works

Excerpts from three standard works from the harp repertoire in Modernism were selected for research application. The sequence of the explanation is chronological.

The first work was written in 1901 by Gabriel Pierné (1863-1937): *Concertstück* for harp and orchestra, Op.39. Composed in three connected movements: Allegro Moderato - Andante - Allegretto Scherzando, with characteristics of the Romantic style and Impressionist features. It was written in honor of the harpist Alphonse Hasselmans

(1845-1912), known as the founder of the French harp school (although of Belgian origin).

The second work is Maurice Ravel's (1875 -1937) piece entitled *Introduction and Allegro* for Harp, Flute, Clarinet and String Quartet (1905). Composed in Impressionist style, it is divided into two connected movements. The work was commissioned by the French harp factory Erard (creator of the pedal harp in 1810). The work was intended to test all the technical features of the pedal harp in competition with the Playel's factory chromatic harp, which was promoting its new instrument with a work commissioned from Claude Debussy: *Sacred and Profane Dances* (1904).

Following the chronological order, we will consider the *Concerto* for harp written in 1953 by Heitor Villa-Lobos (1887-1959). The work follows the musical style of the nationalist composer, adapted to the technical possibilities of the pedal harp. It is written in four movements: Allegro - Andante Moderato - Scherzo - Allegro. This work was dedicated to Nicanor Zabaleta, one of the greatest harpists of the twentieth century, known for his virtuosity.

4.2 The Hands on the Harp

We will use Pierné's piece as a reference to the arrangement of hands on the harp. We will see similarities in the next pieces. Pierné uses in this work a stylistic hand configuration, which became a convention among his contemporaries in Modernism, and which can be considered a real contribution to the development of harp writing.

The perception of the hands as objects/form provides insight into the structure of harp writing. As we saw in the first chapter, “the position is similar to hand extend, as if ready to shake hands, but with the fingers turned inward.” (CHALOUPKA, 1979, p.4). Therefore, we see that there is a visual matrix in the harpist's hand that simply organizes the different fingering configurations in a stable, coherent way, i.e., the perception of the whole like in Prägnanz law (figure 53).

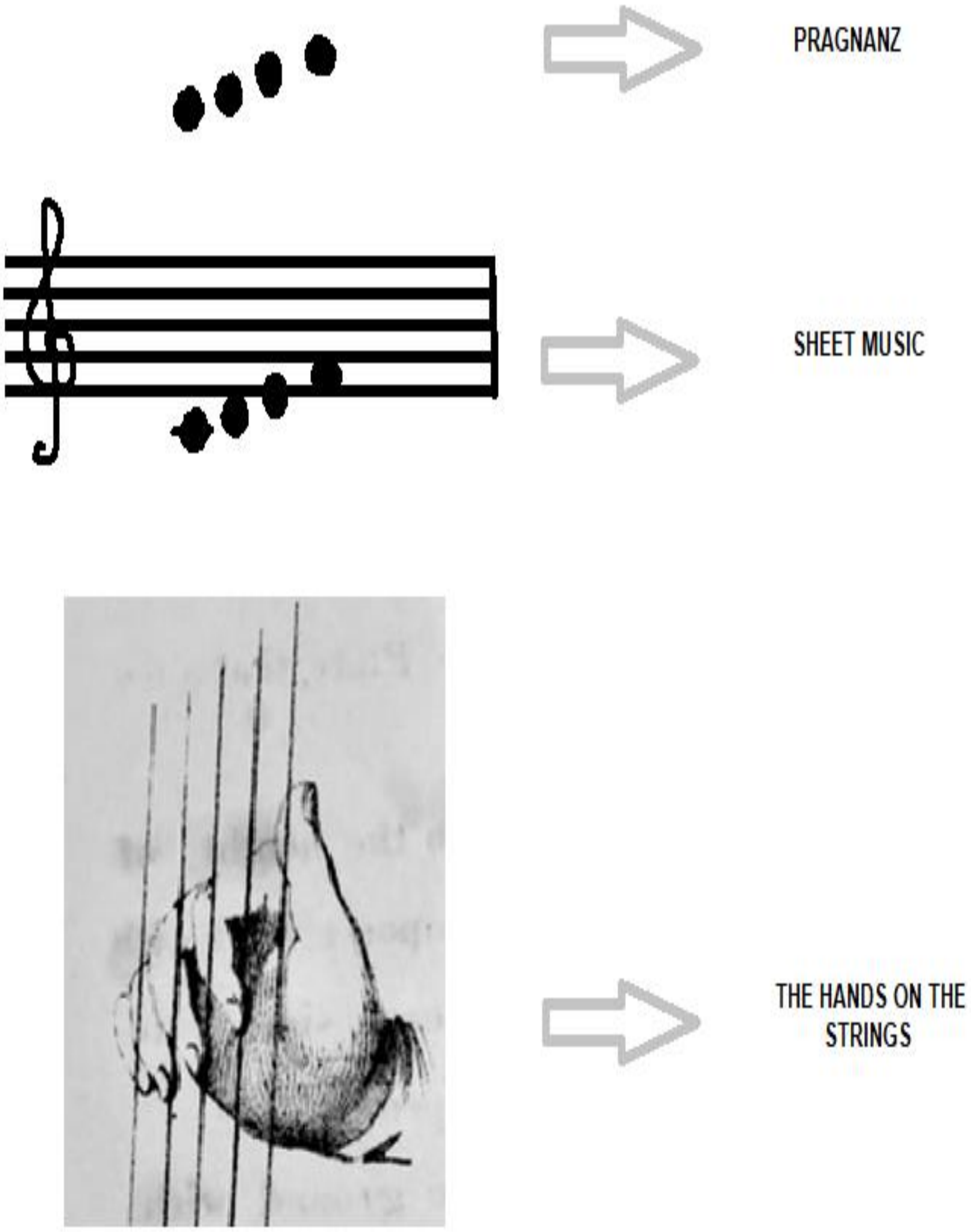


Figure 53. Hands in relation to the notes in the musical pentagram. (BOCHSA, 1840b, p.6).

Attenuating other musical data, the focus of perception basically lies on **what** each hand is doing (Prägnanz) and **how** the hands are idiomatically being used in a linear continuity (figure 54).

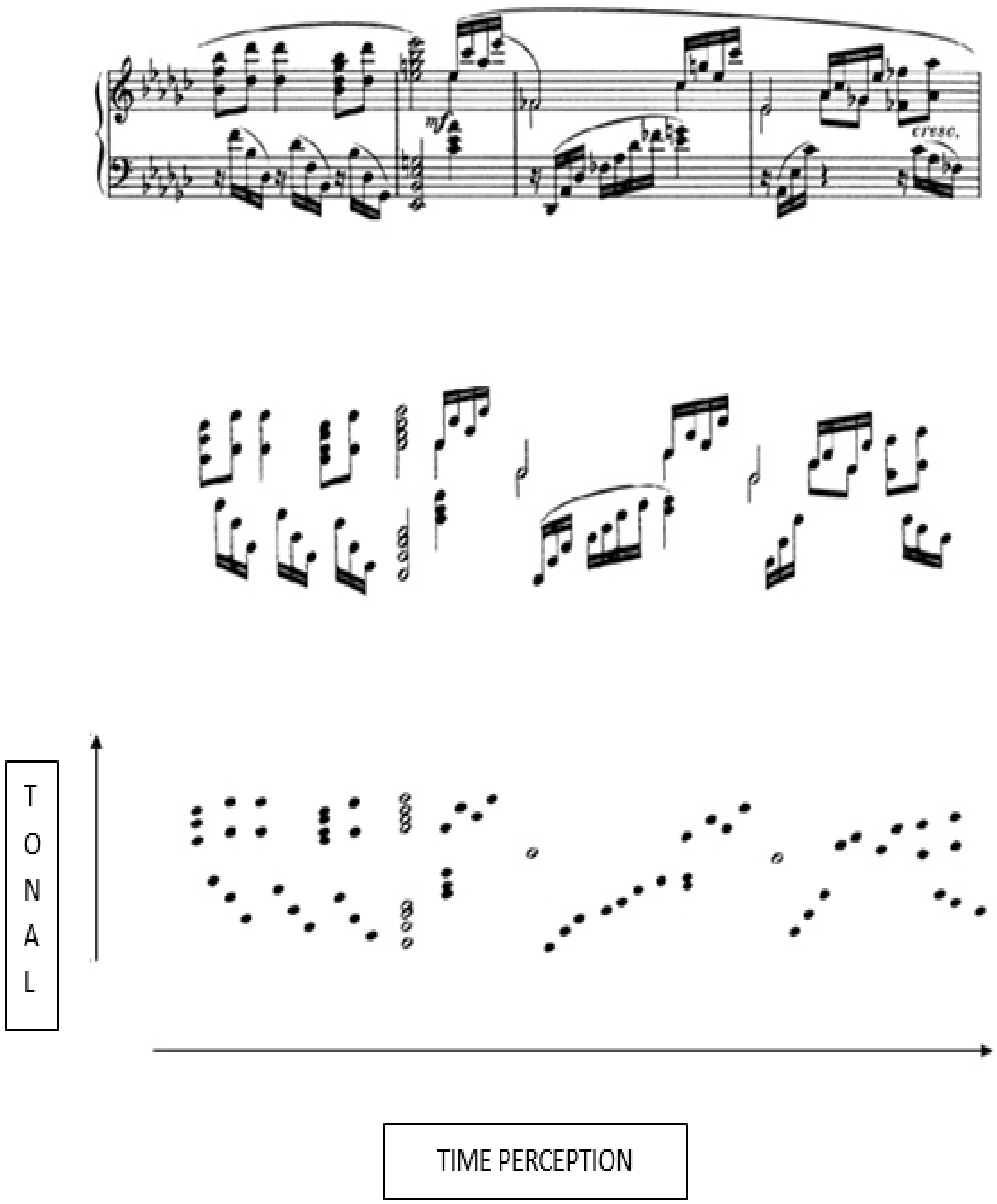


Figure 54. First image: all musical elements. Second image: rhythmic and intervallic perception (attenuation of musical elements cognitively). Third image: Gestalt groupings, which can be observed in tonal perspective (vertical) or temporal perspective (horizontal).
(Adapted from PIERNÈ, 1901, p.8)

Pierné (1901) proposes accurate hand configurations (Prägnanz). In this sense, we can understand what Koechlin (1954) said about harp writing, when he mentioned the use of "a great number of drawings" (p.121) of possibilities for writing, i.e., the hand is suspended with the fingers drawing structures corresponding to the arrangement of the figures arranged on the sheet music.

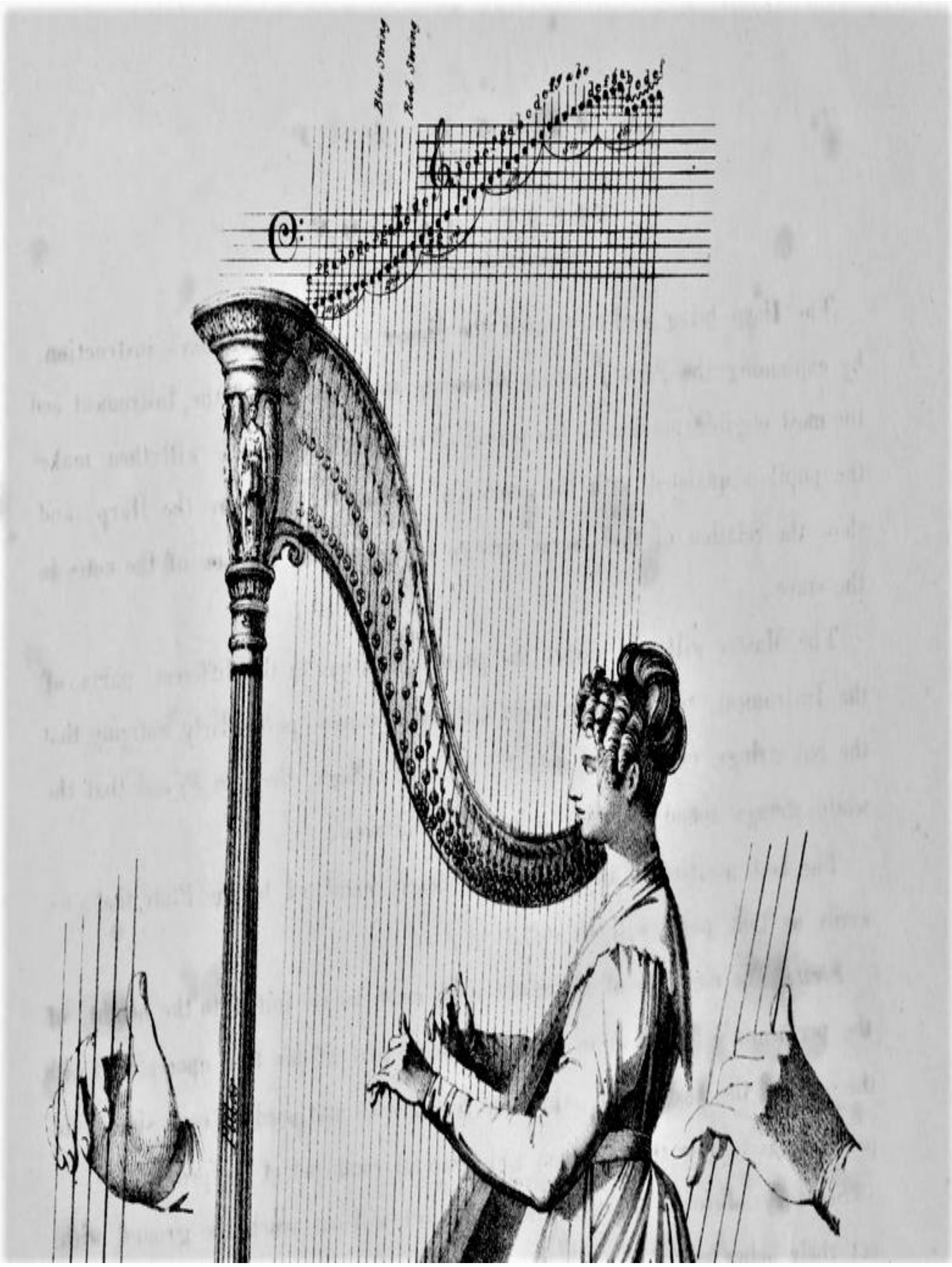


Figure 55. Hands in relation to the notes in the musical staff. The perception of musical notation in visual Gestalt in correspondence to motor Gestalt; consequently, to sound Gestalts (BOCHSA, 1840b, p.6).

We observe, in figure 56, the three Gestalt laws most found and studied by researchers in music: proximity, similarity, and continuity (DEUTSCH, 1982; GROOMER, 2016). The upward movement corresponds to the Prägnanz principle systematically developed with notes of the same chord, which are perceived by the law of continuity in a linear or curved manner. The tonal center is maintained without changing pedals.

Through the perception of the figure-ground, in figure 56, there are parts related in sequential groupings over the pentagrams: four notes for each hand on the strings (proximity and similarity). It is a suggestion of perceptual organization that provides musical fluidity, and can improve the performer's motor sense for agility.

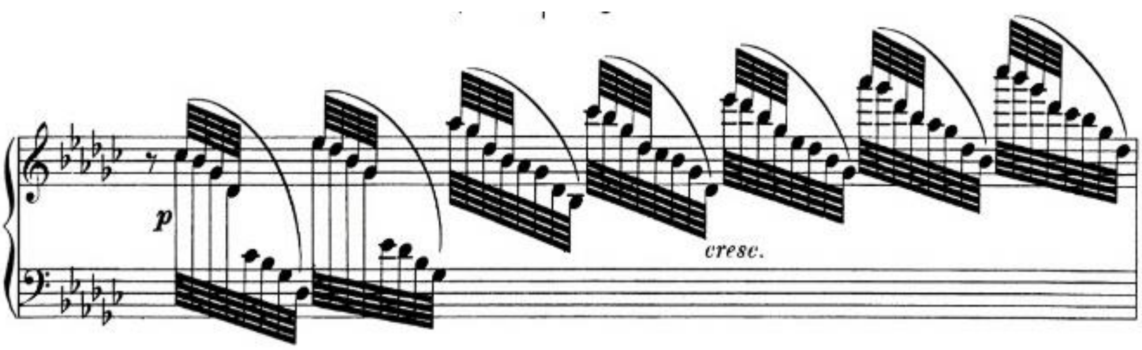


Figure 56. Both hands in sequential downward motion, in an upward linear figure. Four notes for each hand. We can see the three Gestalt laws: proximity, similarity and continuity. (PIERNÉ, 1901, p. 15).

In figure 57, we can observe twice the Prägnanz: in the first five measures, and in the rehearsal number 24. Pierné writes Gestalts, following the beats, the measures, and finally extending them to entire sections.

According to researchers, the best interval range for each hand is a tenth, and the succession of fast notes with maximum extension is to be avoided (CHALOUPKA,1979; KOECHLIN, 1954; MILLER, 2015; REES-ROHRBACHER, 2002). However, Pierné systematically configured (in Prägnanz) the hands with large extension changes (figure 57).

Figure 57. Use of tenths in both hands in rehearsal number 24. Maximum extension in consecutive parallel movements provides the interpreter with mechanical/motor agility (PIERNÉ, 1901, p.11).

In figure 58, the second measure is somewhat different from the previous example. There is a one-measure Prägnanz with three distinct Gestalts forms, complemented by the law of similarity. The first form is structured to be performed at the 1st and 2nd beats, as seen by the proximity law. In this excerpt we can observe a closing Gestalt using both hands simultaneously. Fragmentation is done by pausing and changing register to start another Gestalt. The closing interval of each hand also concludes a Prägnanz.

Figure 58. In the second measure, three Gestalts contrasts in the same measure: (i) first and second beats; (ii) at the downbeat of the third beat, and (iii) fusion figure followed by an eight-note arpeggio (PIERNÉ, 1901, p.6).

In figure 58, after the third beat of the second measure, we see similarity of repetition in the pedal modulation. Pedals A and C are systematically changed by similarity in measures two and three. In those examples we can observe that pedals are conducted following tonal principles (SCHLOMOVITZ, 1978). The pedal harp was developed for the musical demands of the tonal system.

The perception of the whole produces a striking effect upon the performer preparation and practice. In figure 59, we can observe continuous linear, and curved figures, moving symmetrically. Then we can see hand configurations which implicate Prägnanz. And finally, we observe the fingering configurations in proximity and distributed in similarity, developed in groups of three and four fingers.

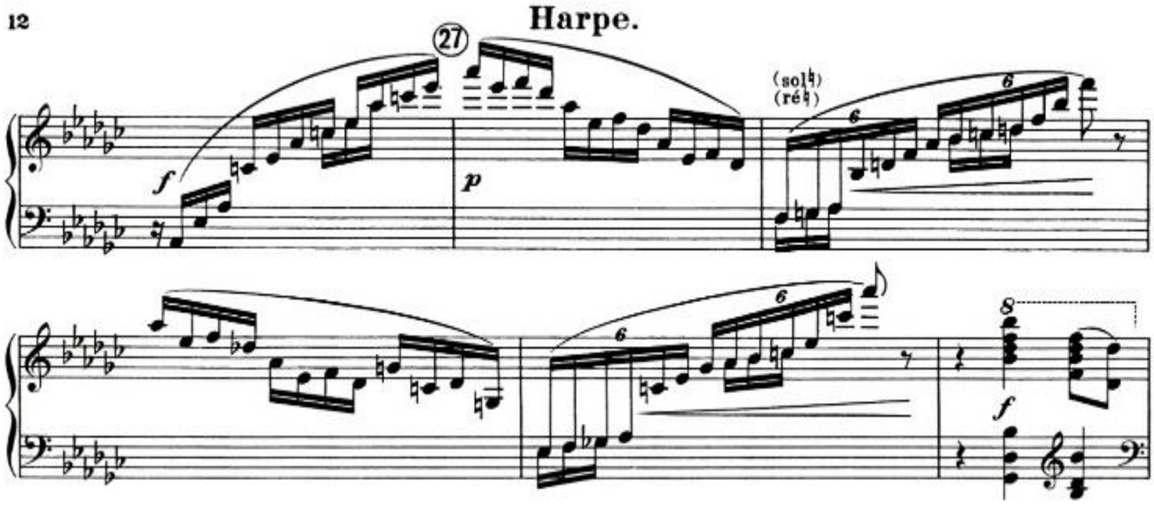


Figure 59. Gestalt contrast, with interval expansion arranged in three and four fingers (PIERNÉ, 1901, p.12)

In figure 60, Pierné establishes a tonality, indicated to the interpreter on top of the staff (E flat major). However, the musical notation follows traditional norms.

Figure 60. Chords that exceed the tenth extension, but slow tempo favors the arpeggiated performance (PIERNÉ, 1901, p.7).

In figures 60 and 61, the closing of each hand (three or four notes by time) may be observed in Gestalts (law of closure). In figure 60, the arrangement is structured in a tonal (vertical) manner, and in figure 61, the structure is arranged in a temporal (horizontal) manner. In figure 60, we see an arrangement in perspective of tonal (vertical) and temporal (horizontal) structure, e.g., in the last measure. In figure 61, we can observe the closing Gestalt in the right hand (e.g., beginning of the second measure) and closing Gestalt and continuity in the left hand (e.g., end of the second measure, and beginning of the third measure, respectively).

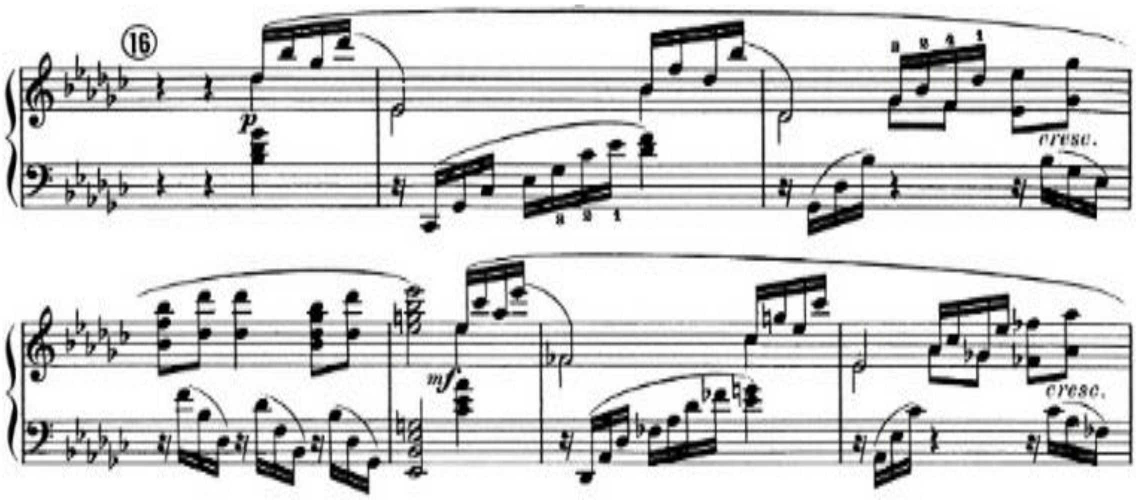


Figure 61. Using three to four notes per hand, interval spacing extended to a maximum of one tenth. (PIERNÉ, 1901, p.8).

4.3 Chords and Variations

Chords on the harp are always played arpeggio, i.e., “all chords not preceded by a special sign must be slightly *arpeggio*.” (SALZEDO, 1917, p.2). In figures 62 and 63 (Pierné and Villa-Lobos, respectively), we can see two interconnected Prägnanz groups, one with eighth notes and another with longer notes, especially quarter and half notes, and we see the use of octaves to reinforce chords, e.g., in figure 62, from rehearsal number 18 on. Such configuration or design is built with a slight variation of tuplets in Villa-Lobos piece, in figure 63.

Figure 62. (PIERNÉ, 1901, p.8, 9)

Figure 63. VILLA-LOBOS (1953, p.4; 60-61)

In figure 64, Ravel uses a similar texture, presenting the melody with the help of chords and octaves. Also note the frequent use of hemiolas.

Figure 64. RAVEL (1905, p.7).

In these examples, we observe pedals being driven by tonal principles (SCHLOMOVITZ,1978). In figures 62 and 63, Pierné and Villa-Lobos avoid pedal modulations in the chord groups following tonal principles. They maintain the tonal field, and use only the possible chords of it. In the case of figure 64, Ravel uses more pedal modulation and cancellation.

In figures 65 and 66, it is observed the systematic configuration of broken chords (Prägnanz) by blocks of intervals (proximity and similarity). Pierné and Ravel maintain the chord configuration for each hand, i.e., with the same extensions for both hands.

Figure 65. (PIERNÉ, 1901, p.2)

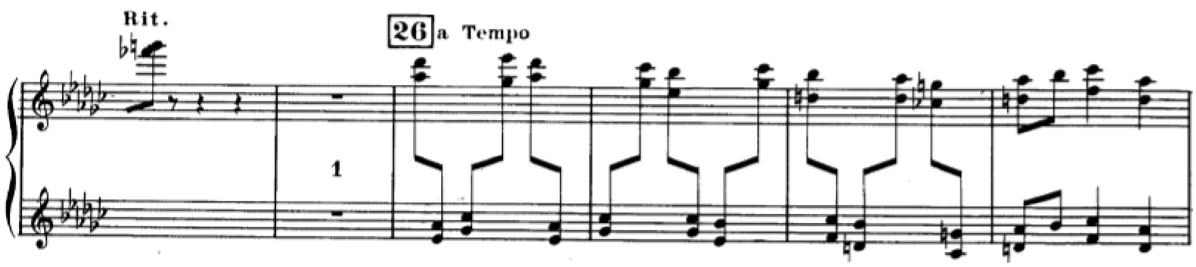


Figure 66. (RAVEL, 1905, p.12)

In figure 67, we observe proximity: Villa-Lobos alternates the grouping of chords for each hand. We can see the mix of vertical and horizontal chords continuously structured in two hands. Prägnanz configurations for each hand corroborate to establish the whole of the perception and fluency of fingering.

Figure 67. VILLA-LOBOS (1953, p.4; 33; 25)

4.4 Grand Arpeggio

We observe that the great *arpeggio* is written following the extension of the hands (Prägnanz), alternating the movement from one hand to the other (law of continuity). The intervals between the fingers (proximity and similarity) must be: “1-2, seconds, thirds, and fourths; 1-3, fifths and sixths; 1-4, sevenths to tenths.” (PISTON, 1969, p.331-332).

In figure 68, we see in each measure a Gestalt which is articulated by the intercalation of the tuplets (fingering: 321,321,321[4]). At measures five and six of the same figure, the arpeggio occurs in last beat with thirty-second notes. We observe that the great *arpeggio* is written following the extension of the hands (321 or 4321/each hand) only by alternating hands.

[4] Fingering: 4 = ring finger, 3 = middle finger, 2= index finger and 1 = thumb.

Figure 68. PIERNÉ (1901, p.13)

In example 69, Ravel uses diverse Gestalts (hand Prägnanz / varied fingerings in proximity and similarity) to create a continuous motion. Note that the created design of the arpeggios (Gestalts) corresponds to the usual range of the hands on the harp strings. Thus, the use of the instrumental expansion and texture corresponds not only to sound aspects (resonance), but also to a type of visual design (technical) or to some finger "choreography." In figure 69, we can also observe that Ravel writes a figure-ground: melody and arpeggios from rehearsal number on. Ravel writes Gestalts with both hands on the same staff (treble clef), using harmonics (bass clef) to emphasize the right hand melody. Ravel consciously used the harp resonance as a sound resource. The resulting harp sonority is drawn visually by the musical notation. Note, in measure six, that Ravel uses an enharmonic note (F#) to avoid note repetition on the same string (Gb).

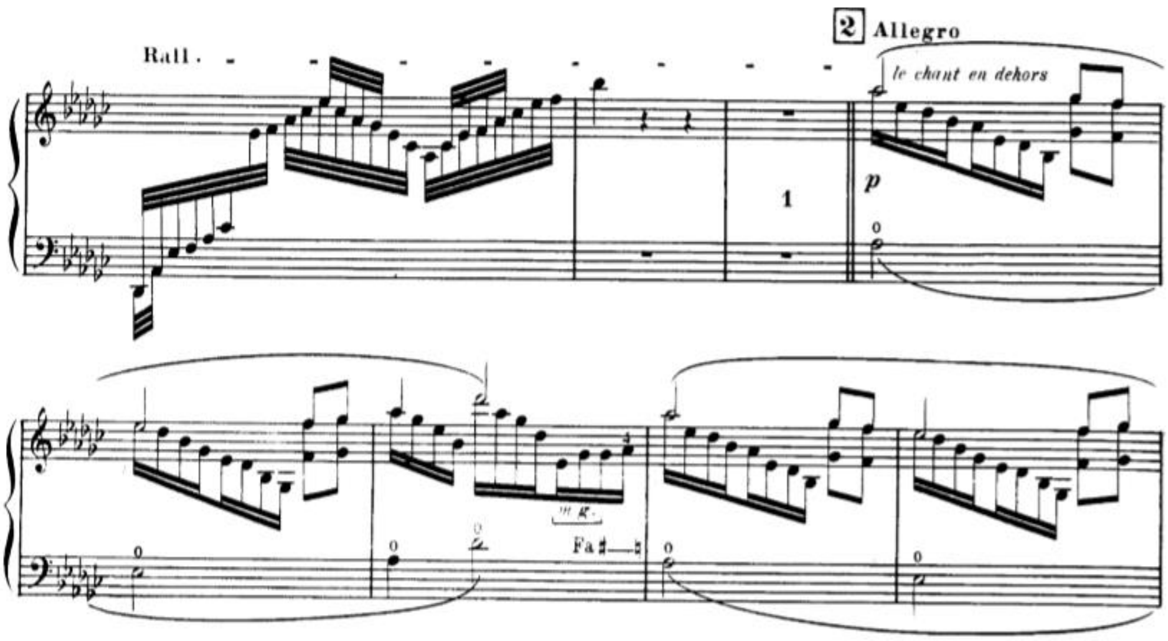


Figure 69. RAVEL (1905, p. 2)

In figure 70, Villa-Lobos uses cascading arpeggios resulting in a grouping effect. In this perspective, cascading arpeggios provide finger Gestalts, e.g., in the first measure, the fingerings 1234 (right hand), and 1234 (left hand) – both downwards –, and later, in same measure, 4321 (left hand), and 4321 (right hand) – this time upwards. Note that the extension of the intervals between fingers and between the hands follow a Gestalt standardization that provides technical balance. Although, due to the great resonance (characteristic of the harp) the systematic distribution of sound at regular intervals, especially in large arpeggio, seems to contribute to a sound and technical balance: Villa-Lobos uses the harp resonance in order to achieve a plentiful sound. Comparing this excerpt with the excerpt showed in figure 69, we can note a similar effect, although Ravel uses a littler range than Villa-Lobos and a melodic reinforcement with use of harmonics in left hand.

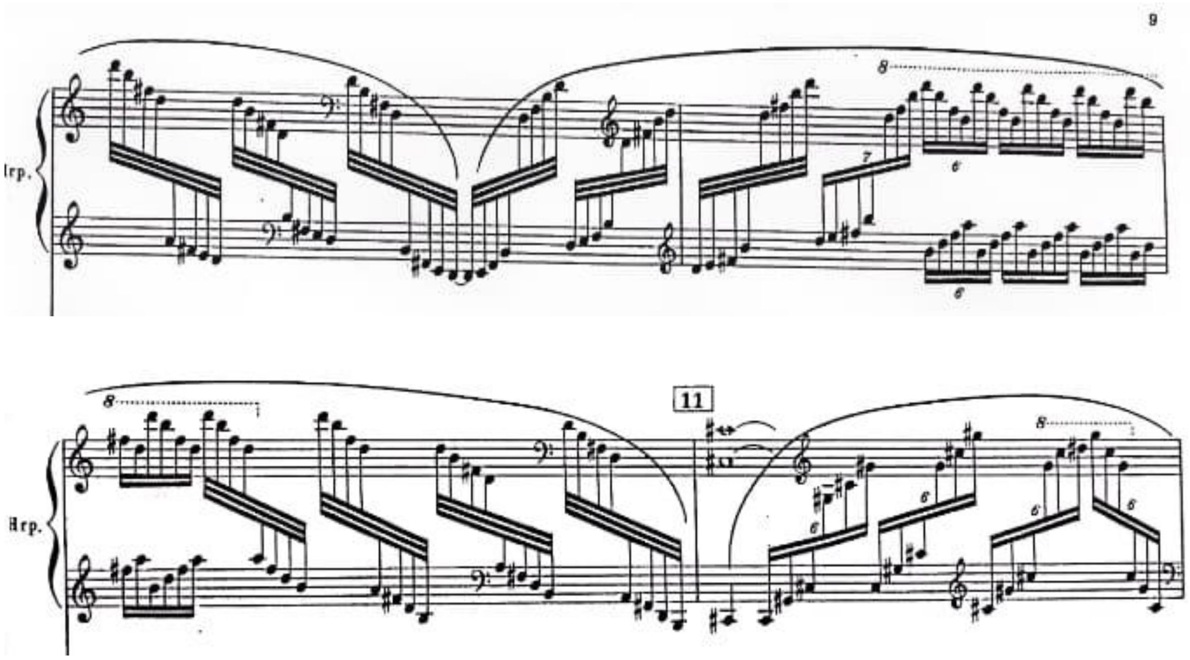


Figure 70. VILLA-LOBOS (1953, p.9)

4.5 Bisbigliando and Trills (or Tremolo)

In figure 71, Pierné uses a kind of *bisbigliando* effect, in this case, a rapid alternation of arpeggios. What characterizes the *bisbigliando* is the rapid alternation of hands/chords or arpeggios). *Bisbigliando* can be viewed as a variation of the *tremolo*. The rapid alternation of two notes can be written in various ways, including the symbol *tr*. The high range is more favorable for these kinds of technique. In figure 71 we can see little arpeggios (Prägnanz) played in rapid alternation of hands in the same register. At rehearsal number 33, the pedals are modulated to another chord configuration (again Prägnanz). Pierné take advantage of the rest in order to operate harp pedals and prepare the strings for the next measures.

Figure 71. PIERNÉ (1901, p.14)

We observe that in figure 72 (rehearsal number 22), Ravel writes a kind of *trill*, but in two different octaves. Ravel, unlike Pierné in figure 71, modulates the harp pedals (from Gb to natural G) during the use of such sound resource.

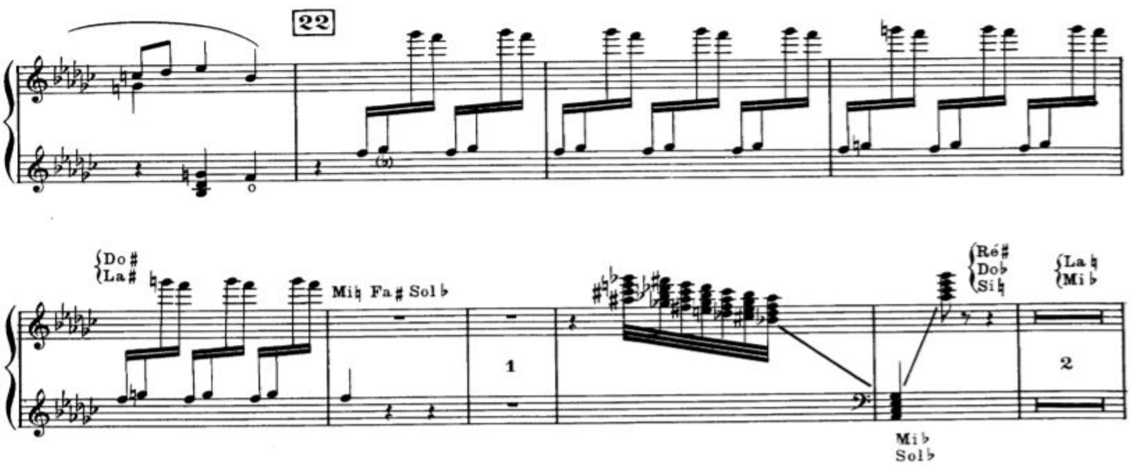


Figure 72. RAVEL (1905, p.11)

In figure 73 (Villa-Lobos), we can observe the regular configuration of the hands (vertical Prägnanz). In the first three measures, there is one chord for each hand in each measure, moving in horizontal (harmonic) continuity.

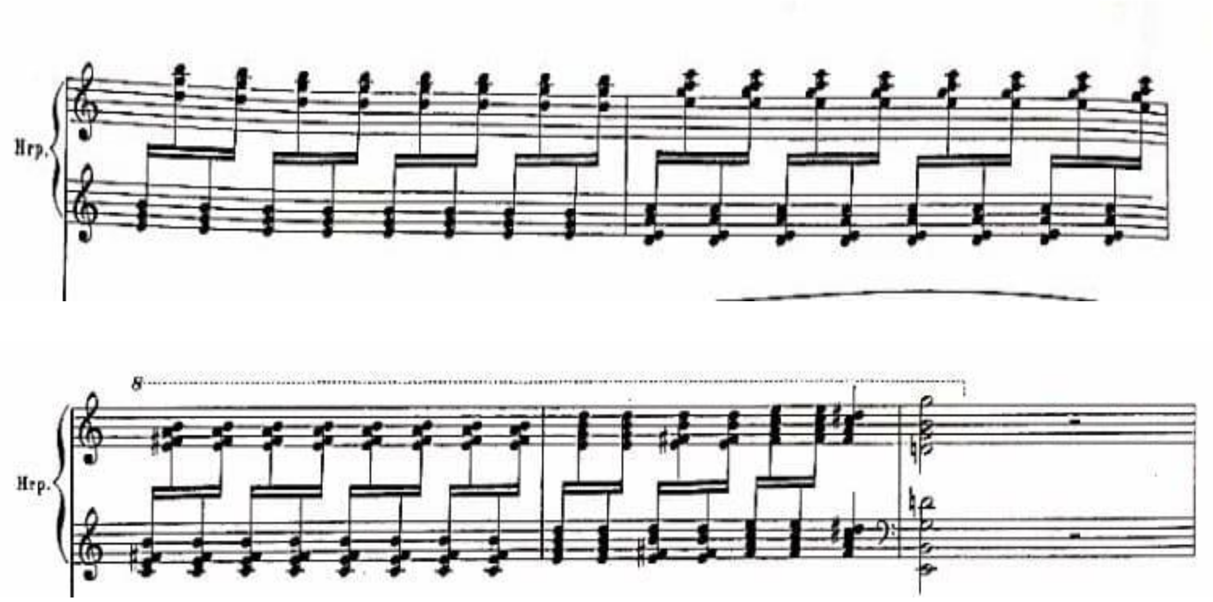


Figure 73. VILLA-LOBOS (1953, p. 56)

We can observe that *bisbigliando*, *trills* or *tremolo* forms are repetitive (hand position/Prägnanz) and continuous.

4.6 Scales

On the harp, the hands play scales always with the same fingering, i.e., 4321 (both hands, upward scales), and 1234 (ditto, downward scales). Scales can be doubled in parallel octaves.

In figure 74, Pierné alternates the use of steps and leaps in parallel octaves. Such configurations are important references for grouping in the process of visual and motor perception. In this figure, the pedals are operated in parallel with harmonic modulation and visual Gestalts (Prägnanz of hands). There are pauses for changing pedals, except in measures 10 (natural D to D#) and 12 (natural F to F#).

Figure 74. PIERNÉ (1901, p.5)

In figure 75, Ravel uses motives following scale degrees and groups them visually in each measure. Similar forms of such grouping can be found in Pierné (figure 62) and Villa-Lobos (figure 63).

Figure 75. RAVEL (1905, p.5)

In figure 76, Villa-Lobos uses both hands, writing the scale in parallel thirds (4321, upward). Note that during the scale there is no pedal changing.

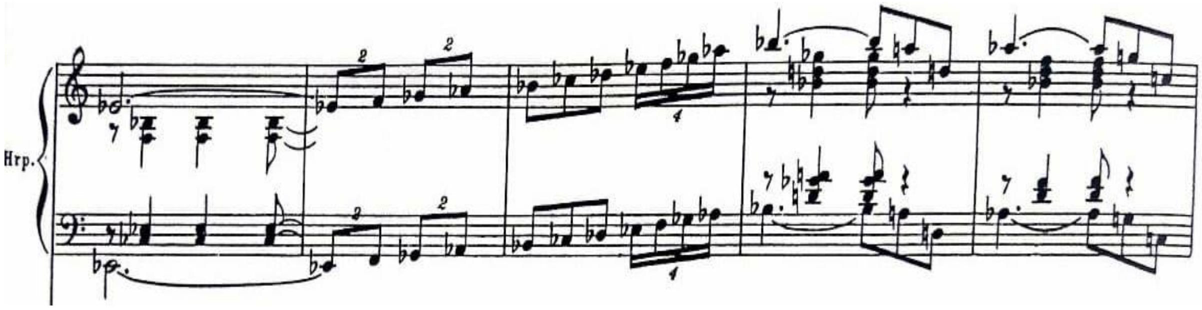


Figure 76. VILLA-LOBOS (1953, p.32)

4.7 Glissandos

The glissandos are a variation of the scale, simply modifying the speed of its execution with the sliding of fingers on the strings (KOECHLIN, 1954). The process of enharmonization by the pedals turns glissandos (in scale configuration) into glissando of chords (SCHLOMOVITZ,1978).

In figure 77a, Pierné writes all notes of glissando. We can observe that he fixes a diminished seventh chord on B (B-D-F-Ab), suggesting enharmonic notes with tone repetitions: F is played as F and as E#; Cb is played as Cb and as natural B; Ab is played as Ab and as G#. The Gestalt is limited by the chord glissando in a linear sense. In figure 77b, Pierné (1901) writes the entire scalar glissando (Db major).

a.

b.

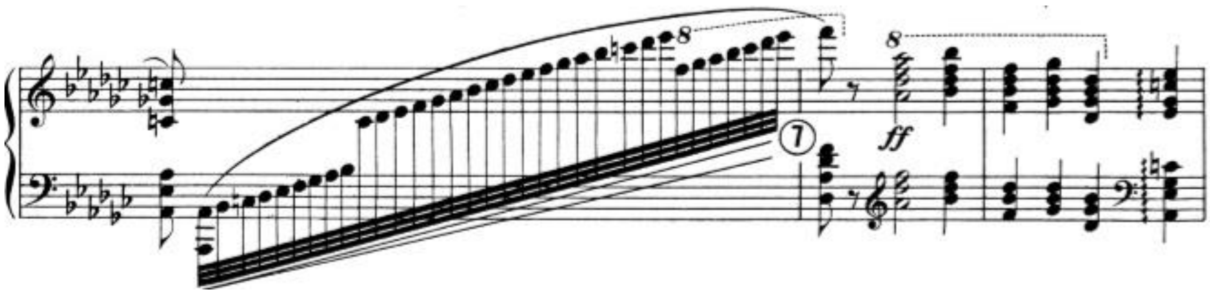
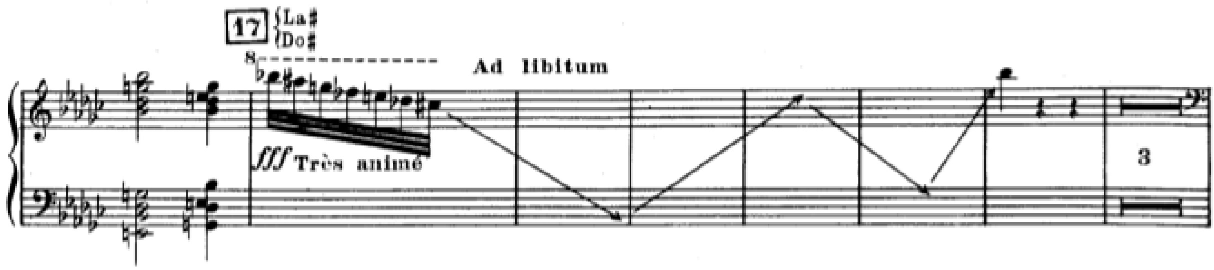


Figure 77. PIERNÉ (1901, p.4; 6)

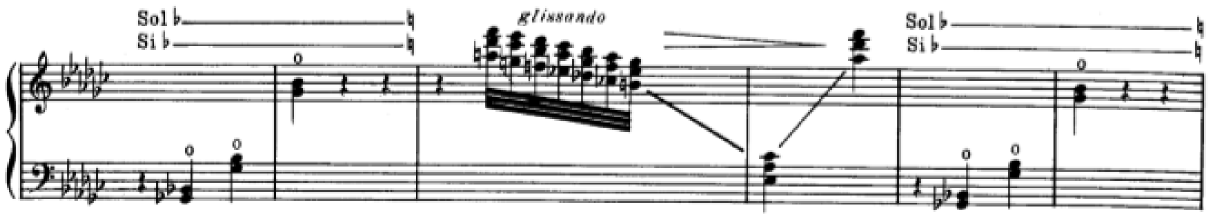
In figure 78a, Ravel uses arrows to indicate the approximate range of *glissandos*. The composer establishes a glissando with a C# diminished seventh arpeggio with the help of enharmonic notes: Bb=A#, Fb=E, and Db=C #.

In figures 78b and 78c, Ravel (1905) develops other sound effect, using chords glissandos. We observe a fixed Prägnanz of hands (“what”).

a.



b.



c.

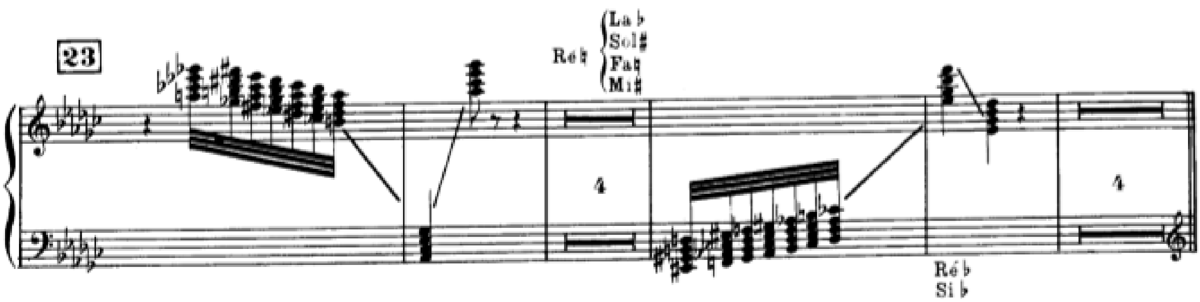


Figure 78. RAVEL (1905, p.7; 6; 11)

In figure 79a, Villa-Lobos (1953) writes a glissando to accentuate a sequence of notes. In this example the glissando also establishes the pedals/notes of the harmonic field that follows. In figure 79b, he writes the glissando with lines, suggesting the hands movement on the strings, maintaining the tonal field.

a.

b.

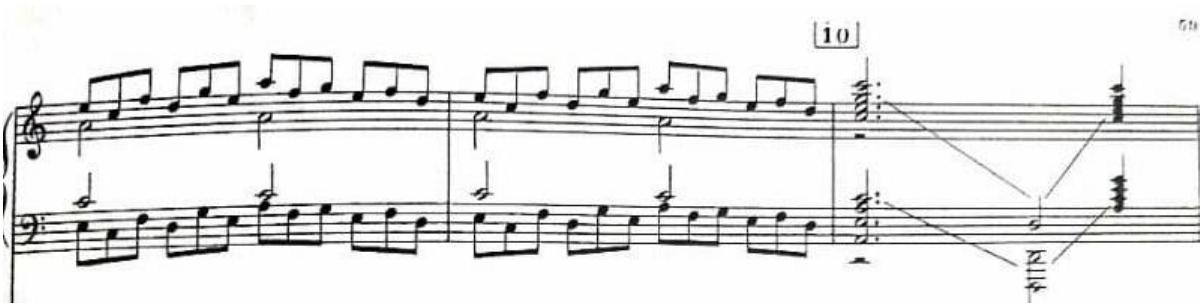


Figure 79. VILLA-LOBOS (1953, p.1; 5).

4.8 Harmonics

The use of harmonics should respect predominantly the range of each hand on the harp, i.e., between G2 and G5 (CHALOUPKA, 1979; ALEXANDER, 2008). Harmonic notes can be played as single notes or by both hands. The harmonics by Pierné, figure 80, are used in arpeggio on both hands.

Figure 80. PIERNÉ (1901, p.15)

In figure 81a, Ravel punctuates the harmonics in a linear Gestalt (set of three measures). The two hands in parallel octaves, follow the harmonics in scale degrees together.

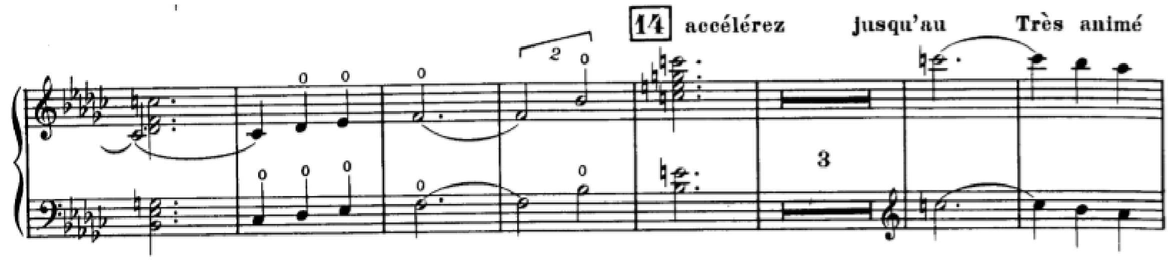
In figure 81b, Ravel punctuates the left hand with harmonics and maintains the similarity of chords and intervals in the right hand (Prägnanz). The hands are arranged on figure-ground, i.e., harmonic sounds and natural sounds.

In figure 81c, we observe enharmonized glissandos in the right hand and punctuated notes in the left hand, i.e., a figure-ground context between the right hand and the left hand. Ravel writes eight-note rests at the beginning of first and second measures, so that the harpist can prepare pedals change.

In figure 81d, Ravel also uses the perspective of figure-ground to combine harmonics with enharmonic notes, maintaining the Prägnanz of three or four notes. He uses tuplets and eight notes to slow down the rhythmic speed, but maintains the harmonic field in order to create resonance.

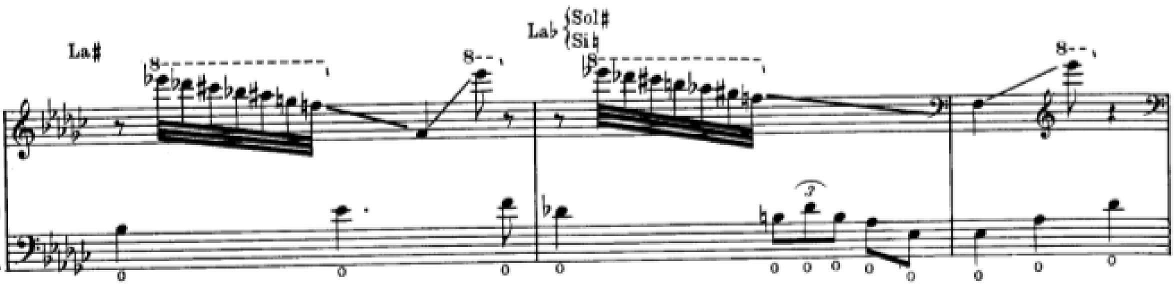
In figure 81e, Ravel uses an enharmonic glissando to introduce a sequence of intervals played one time with harmonics and one time with usual sound. Ravel writes pedal changing in the way Salzedo (1917) would suggest later: “the pedals is scrupulously indicated in accord with the rhythms of the musical expression.” (SALZEDO, 1917, p.4-5). Ravel changes pedals another time for the last arpeggio in this figure.

a.

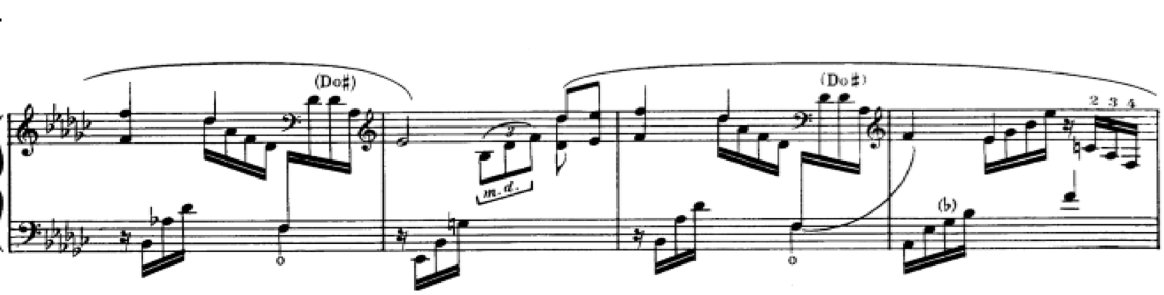


b.

c.



d.



e.

Figure 81. RAVEL (1905, p.7; 6; 11)

In figure 82, we can observe by symmetry that Villa-Lobos also uses the configuration as Ravel did in figure 81e, i.e., the repetition of third intervals played one time with harmonics and one time with usual sound. However, Villa-Lobos keeps the harmonic fields (without pedal modulation) until measure eight of this figure.

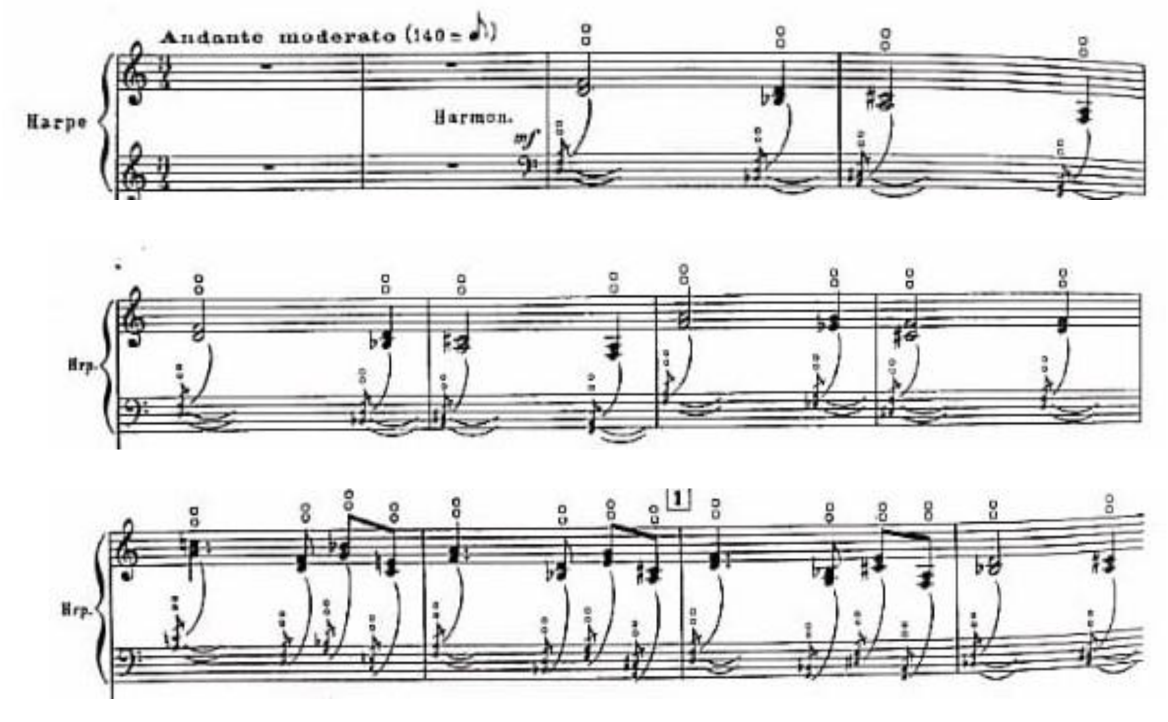


Figure 82. VILLA-LOBOS (1953, p.14)

4.9 Variation

In figure 83, we can observe that Pierné writes a rapid succession consecutive intervals (thirds) for the right-hand and arpeggiated chords for the left-hand. Macdonald (2004) states that the consecutive intervals in rapid succession “can be played only descending, enabling the thumb to slide from one upper note to the next while the lower notes are taken by the other three fingers.” (MACDONALD, 2004, p.71).

Figure 83. PIERNÉ (1901, p.3)

In figure 84, Pierné begins the excerpt with an arpeggio, alternating left and right hand. At rehearsal number 8 of this same figure, both hands play in similar movement a tuplet a range of tenth (Prägnanz). The upper voice (with stems up in both hands) indicates the melodic Gestalt.

Figure 84. PIERNÉ (1901, p.5)

In figure 85, Ravel explores the proximity in both hands. The arpeggiated figures in left hand are separated from another through rests, and the melody in right hand is conducted with chords and octaves. The rests in left hand indicate closure and Prägnanz.

Figure 85. RAVEL (1905, p.6)

In figure 86, from second measure on, we can observe a similarity with Ravel's excerpt in figure 85. Both write two distinct sound layers, each one played by one hand.

Figure 86. VILLA-LOBOS (1953, p.59).

4.10 Considerations

It was observed that the mental percept, with focus of perception on visual objects (musical notation) in the perspective of Gestalt Theory (WERTHEIMER, 2012) contributes to insights and mapping the structure of the sound results of pedal harp performances. The three selected works show technical similarities due to the developments of the harp technique during the Modernism of the first half of twentieth Century.

We note that there are Gestalt fingering configurations implicit in the harp score, which are only empirically observable by watching a harpist performance. Studying the sensory and perceptual systems of humans, we can infer that the visual stimuli of musical notation can be deep interwoven with motor (re)actions on the part of a good instructed performer.

Hands positions and movements on the harp find an image by similarity thanks to the convention of Western musical notation. Musical drawings are mainly observed by visual Gestalts of proximity, similarity, and continuity.

We observe that the visual design of the musical notation for the harp corresponds to the sensory motor design (figure 53 and 55) and by equivalence to the sound design. We can infer an audiovisual and geometrical design integration in musical writing of pedal harp.

Musical Gestalts (structured with the help of chords, glissandos, arpeggios, etc.) are almost always used sequentially in whole sections. Intervals are unfolded into chords, arpeggios, grand arpeggios, and into effects such as *bisbigliando*, or *tremolo*. The scales are presented in one voice, in parallel motion, or extended to *glissandos*.

The perception of harmonic (vertical) or rhythmic (horizontal) structuring are aspects developed according to the aesthetics and musical style of each composer (observed by musical enculturation).

All mentioned details or sound resources and their attentive observation in score should help harpist by organizing the visual perception of the musical score and preparation of its performance.

Deutsch (1982) and Mesquita (2016) warns us about the perception of musical organization at other structural levels. Deutsch (1982) states that the musical grouping in Gestalt Theory is a first level of abstraction, while Mesquita (2016) shows different possibilities of segmentation analysis with the help of the concept of musical parameters.

We could observe in this research some aspects of the first level of abstraction or parametrical structures of musical organization adopted by Gestalt Theory. We can apply a similar process to other levels of abstraction or parametrical structure of the musical organization, maybe hierarchically or sequentially. However, more research is needed for such purposes.

5 FINAL CONSIDERATIONS

We could see in this research aspects of the cognitive processes implicit in the musical notation of the pedal harp. The creation of a mental percept approached by Gestalt Theory, clarifies and indicates cognitive aspects involved in the visual organization of harp writing, elucidating information that can corroborate a better performance preparation and the creation of more idiomatic musical compositions for the harp.

It was observed that exemplar modern works, like the *Concertstück* for harp, Op.39, by Gabriel Pierné (1901), *Introduction and Allegro*, by Maurice Ravel (1905), and *Concerto para harpa*, by Heitor Villa-Lobos (1953) present all technical resources explained in instrumentation/orchestration treatieses. The musical notation for pedal harp can be seen as visual idiomatic drawings (Gestalts) and such drawings were compared and associated to hand configurations and movements (Prägnanz). We can deduce that many writing mistakes and the frequent idiomatic inadequacies about the use of pedals could be avoided if such comparisons were understood by composers.

The pedal harp is an instrument built in nineteenth century, adapted to the temperate tuning. Therefore, the observation of the tonal principles (e.g., the rules of harmonic progression in the circle of fifth) contributes to the proper use of the pedals. The enhamonization can be used in more complex harmonic progressions.

At the end of the research, we observed that mental percept is only a first moment of human perception, and that there is a vast possibility of other levels of abstraction or parametric structures in the brain to observe the musical phenomenon. We believe, however, that the approach to mental percept provided by Gestalt Theory presents us an enlightening solution to the problem of perceptual idiomatic inadequacy in the pedal harp writing.

Additional researches that would include semantic aspects of cognition and knowledge of the musical enculturation process are a perspective for a more elaborated and deeper understanding of the aspects discussed in this dissertation.

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