Chapter

Acoustics from Interior Designer Perspective

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Abstract

Should we consider the acoustics as engineering science or as architectural elements or as interior design applications? The main purpose of this chapter will focus on the differences between the three aspects of the acoustics with a special focus on the interior acoustical design. The arguments that favor the acoustic in each field are many. This chapter will clarify, strengthen, and explore the importance that has the acoustic study for the interior designing layout. From the historical eras where only material schemes were used, the acoustical treatment reached a great achievement. Nowadays, electrical, acoustical devices took place in different situations where only the materials could solve the acoustic needs. The considerations of using the electrical-acoustical devices remain under request, while their usage, only in specific conditions, a topic to highlight in this chapter.

Keywords: acoustics for interiors, soundscape, environmental acoustics

1. Introduction to acoustics

Acoustics is a multidisciplinary field where many specializations cohere. The more the knowledge advances, the more the subfield growths and thus the belonging matter struggle. Acoustics comprehends a numerous profession such as architecture, engineering, physics, electronics, speech communication, mechanical engineering, medicine and speech communication, music and arts, and oceanography. Acoustics is a title, which today needs to be more complex as terminology, as all of the mentioned professions consider it as their own.

Acoustics is associated until a near date to the engineering. However, nowadays, many titles raised to identify the stipulation of the specific field better.

The soundscape is the acoustics that deals with the unconscious effects of sounds and the surrounding sound background having precise psychological effects.

Acoustical environment is the interior design application of the sound behavior within the interior and the different physical reactions on the human functions. Acoustical oceanography is the study of the underwater sound. Acoustical engineering, like science, belonged to the engineering; then by the advancement of information, it splits to mechanical waves, where the science of sound and vibration across the technology exists. Acoustical engineering, as well, has a direct relationship with the sound control through electrical devices.

Interior acoustical design cooperates some of the previous elucidated aspects, the soundscape, the acoustical environment, and the electrical sound systems, where all are integrated into the interior spaces based on their functions.

2. Acoustics and related field of specializations

When and how does humanity recognize acoustics?

The applications of the acoustics start from the historical eras for a diversity of purposes. From the prehistorical eras to the modern decades, especially with the emerging of the science and the recent innovations, the science of sound focused on informing, healing, and amusing. The main purpose of acoustics in design is the hearing of the required sounds. The diversity of disciplines, which deal with the acoustics, arises through some fields. R. Bruce Lindsay created "Lindsay's Wheel of Acoustics" (**Figure 1**) [1]. This wheel shows the fields of acoustics starting with the four broad fields of earth sciences, engineering, life sciences, and the arts. The outer circle lists the various broad disciplines one may study to prepare for a career in acoustics. The inner circle lists the fields within acoustics to which many fields naturally lead. The highlighted area shows the room acoustics, or the interior acoustical design, as well as all the related fields affecting to some extent the interior acoustical design clarified within this chapter.

2.1 Acoustics in engineering

Acoustic engineering is the branch of engineering dealing with sound and vibration, on its physical aspects. It is the application of the science of sound and vibration, in technology, typically concerned with the design, analysis, and control of sound. It also covers additional uses of sound, from the use of ultrasound in medicine to the programming of digital sound synthesizers. Acoustics, like engineering,

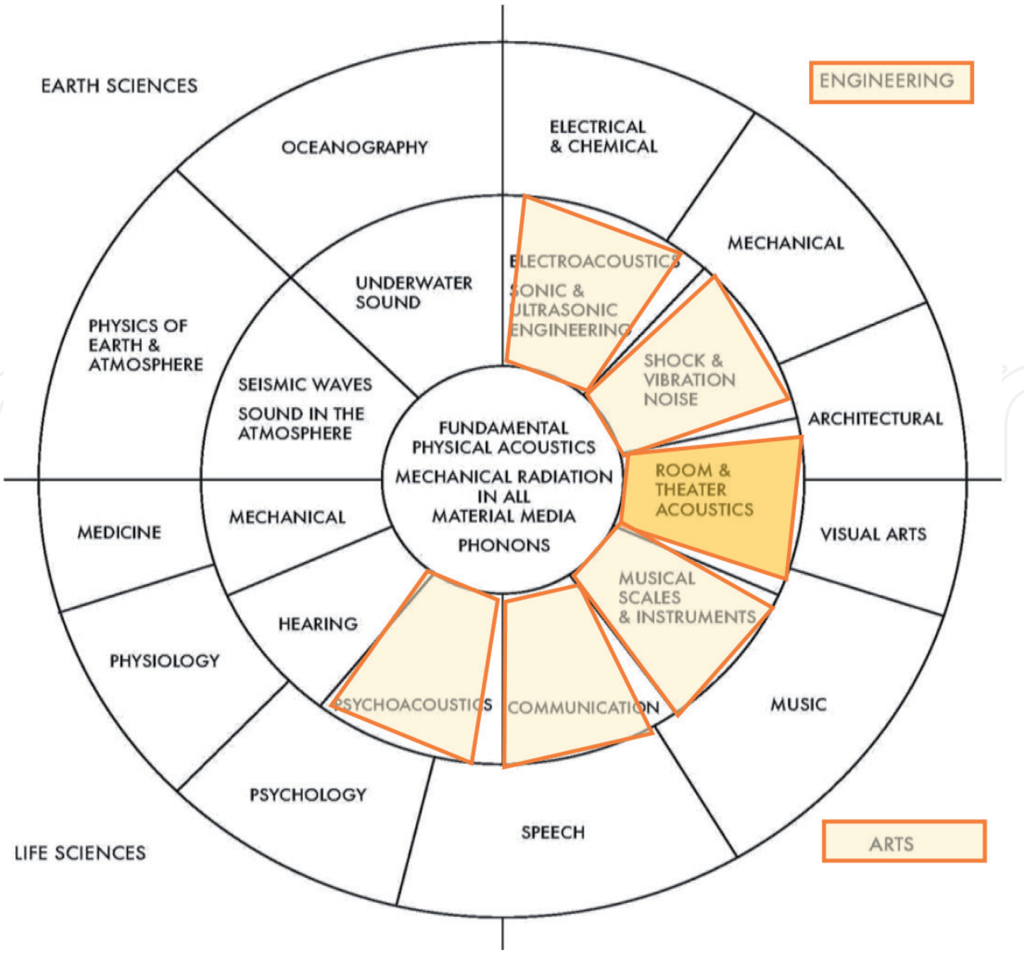

Figure 1.
Lindsay's wheel of acoustics.

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deals with the electroacoustic elements, which are the electrical sound systems (microphones, headphones, loudspeakers, sound systems, sound masking, noise control, recording, and reproduction of sound). Acoustical engineer interprets with the sound from the physics perception. However, this side of the acoustics does affect the interior, as part of the whole design.

2.2 Acoustical design in the historical eras

A long time before the recent advancements and technologies, the different civilizations managed the available science they acquired from their previous ancestors and developed their daily life needs. By surfing among the different historical eras, we will discover that they had many solutions to solve their acoustical needs. Some of these solutions were, as per nowadays rules, architectural, and others were interiors!

From the prehistorical to the modern eras, diverse interpretation were used to enhance the sound level and the sound projection within interior spaces for the benefits of the event. Most of these events were educational, and their purpose was informing the communities with specific attained knowledge.

2.2.1 Acoustics in the prehistorical era

At the beginning of civilizations, the hunters, once back to the village, reproduce the hunting scenes for their young generation to teach them the procedures and tactics. They start to realize that the circular layout is the best to make others see and hear the message. They meet in a circular layout; either they are in the open air or their tents (**Figure 2**).

2.2.2 Acoustics in the Greek and Roman eras

By the Greek and Roman eras, the communities' fascination was the philosophy and the poetry. They build the amphitheaters, where speech and music could act, to communicate their knowledge. The shape of these buildings was to enhance the sound dissemination within the space (**Figure 3**). They used the open air to add extra reinforcement to the sound projection. At the same time, the open air works as a reflection to amplify their speech sound, in addition to the "horseshoe" plan layout and the level in the amphitheater style of interior layout, which enhances the acoustic performance of the place [4]. The steps of the audience area act as amplifier additionally to the rule of "Seeing ensures Hearing." As much, the person sees the stage as much the sound reaches the person without obstacles, although it


Figure 2.
Hunting scenes in the prehistorical era, in tents and open air [2].

Figure 3.
The amphitheater (the Greek Odeon of Herodes Atticus in Greece on the right and the Roman Theater of Mérida in Spain on the left) [3].

needs some reinforcements. The high edifice was using the background of the stage performance as backstage services spaces, stage set design, and main reflection elements to strengthen the sound on the stage.

2.2.3 Acoustics in the Islamic eras

The Islamic civilizations lasted for many eras and were a mix of religious reverence, science, and art lifestyle. They used the sciences as a base to all their inventions and creations under the spiritual beliefs. The great palace of Ālī Qāpū relieves new challenge of acoustical behavior and treatments. Built in the early Safavid style was the six-story Ceremony Hall (**Figure 4**). The muqarnas and cutout designs function to decrease reflections and act as a sound diffuser for the enhancement of the religious songs without echo, in beauty and functionality. Due to the distinguished advancements of mathematics, especially the algebra and physics, the results are magnificent [5].

2.3 Acoustics in architecture

Architectural acoustic design starts from the acoustical engineering. The connection between the physics and their applications when Wallace Clement Sabine, father of the modern building acoustics, gets the attention of the sound in the different lecture halls in Harvard where he studied physics science. Absorption formula title—Sabine's Formula—honoring his hard studies and experiments to reach today science the Acoustical Design in Buildings. The acoustics of buildings face several obstacles: the modern design trends, the type of materials, the mechanical systems in the buildings, and the surrounding level of noise.

The modern trends in design open up the spaces, no matter the functions and the privacy required for specific zones. Accordingly, the masking noise between the interface and the user concentration disappears.

Figure 4.
The six-story ceremony hall in Ālī Qāpū palace in Isfahan, Iran.

The building materials become economic in terms of structural properties in favor of space and cost saving. Such products create extra load on the noise production and prevent a safe environment for the users.

Mechanical systems in the buildings are necessary with today's climate. The air-conditioning systems, the elevators, and the ventilation are all components that contribute to the noise pattern of the buildings.

The level of noise's pollution created by today's lifestyle that is transmitted to the building add additional problems and multiply to a disastrous extend the noise pollution of our environment.

These problems are the main concern of the architectural acousticians.

2.4 Acoustics in interior design

Interior design, as specialization, dates to 1890. Elsie De Wolf developed the Colony Club in the US, and from then, it becomes a profession. The architect—the worker' supervisor in Latin—was in charge of all the building details, including the interior. Well, the interior design is the profession that cares, protects, and sustains the human life in a healthy, green, and safe environment. The interior acoustical intermediate that is appropriate to the function, reaching the audience in proper level to success the communication, without disturbing or even harming the users hearing, is a prosperous acoustical design. The classification of the interior spaces could lead to a better understanding of the role of the acoustical design to succeed in the functionality of the space. The interior acoustical design differs from the spaces where speech intelligibility is necessary to the spaces where quietness is vital, to spaces where the music needs enhancements, to spaces of private communications, and to spaces where public announcements take places. Each of these categories will require a specific combination of materiality schemes that balance between the physical properties and their quantities to provide an adequate acoustical environment [6].

2.4.1 Spaces for speech intelligibility

Speech clearness is vital in a specific type of functions. Without speech intelligibility, classes' success could fail. Teacher explanations, court sessions, and board meetings are functional, practical examples where speech is the key role of their success. Large institutions need clear discussions to make efficient decisions. In the court, when the speech is not clear, many judicial problems could take part from innocently. Such spaces need clear speech with no reflection nor echoes. In such functions, the number of absorber materials should increase in favor of the reflectors. The absorption material scheme when exceed, will produce a harmful background and thus will require more effort from the sources to enable the audience to hear. Therefore the introduction of some diffusers is necessary to balance the acoustics performance (**Figure 5**).

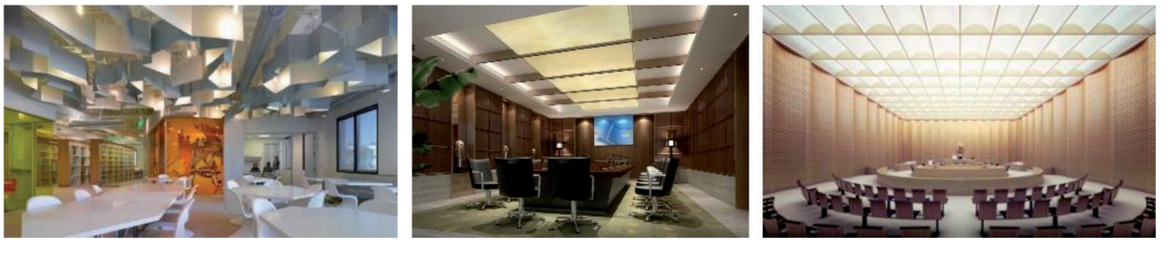

Figure 5.
Examples of classroom, boardroom, and court room where the speech intelligibility needs many absorbers.

2.4.2 Spaces for quietness needs

Sick peoples are the top users of quiet spaces where they take their recovering period. Museums are the place for specific levels of emotional entertainment or educational session; both of them are a relatively individual requirement and need high quietness levels. Classrooms are the spaces where instructors and students met for the educational processes environment. All these spaces (**Figure 6**) do require the best level of quietness background to achieve their specific functions. Hospitals, museums, and classrooms need a quiet environment. Such acoustical needs require more than the interior material scheme, it needs the isolation treatments to reach the quietness level.

2.4.3 Spaces for music enhancements

Recording studios, musical halls, and theaters are the locations of musical enhancement functions. Each of these areas needs different acoustical treatments to reach a vital level of sound. Studios need absorption layout to remove any reflection possible. While the musical halls, where live music takes place, requisite a mixture between the reflection and diffusing materials to reach the life feeling of sound without echoes nor masking of sound (**Figure 7**). Theaters are relatively difficult as they could host drama performance and musical performance.

2.4.4 Spaces for privacy needs

Private discussion occurs in human resources offices, in a medical clinic, in residential spaces, and police stations. These environments need high absorption

Figure 6.
Examples of museum, hospital, and living room where the quietness needs much absorbers and isolations.

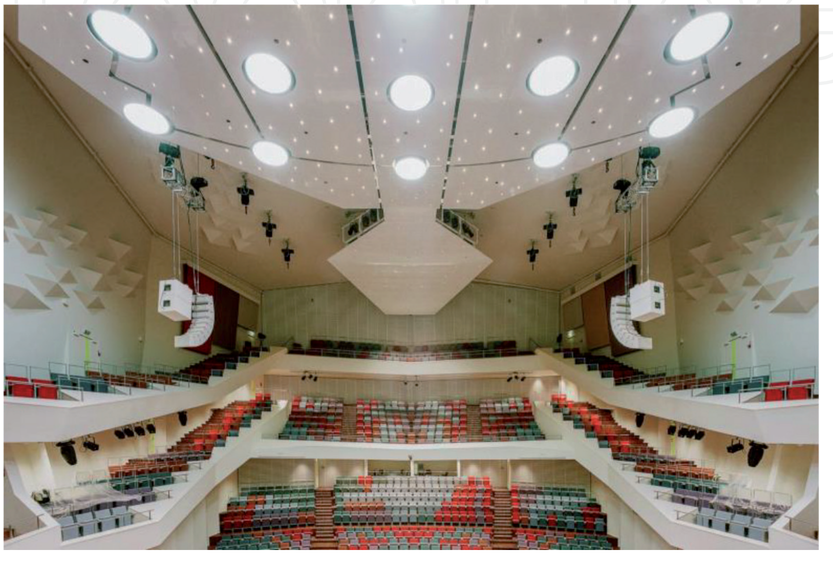

Figure 7.
Examples of concert hall where the music needs to be enhanced through the reflectors and the diffusers.

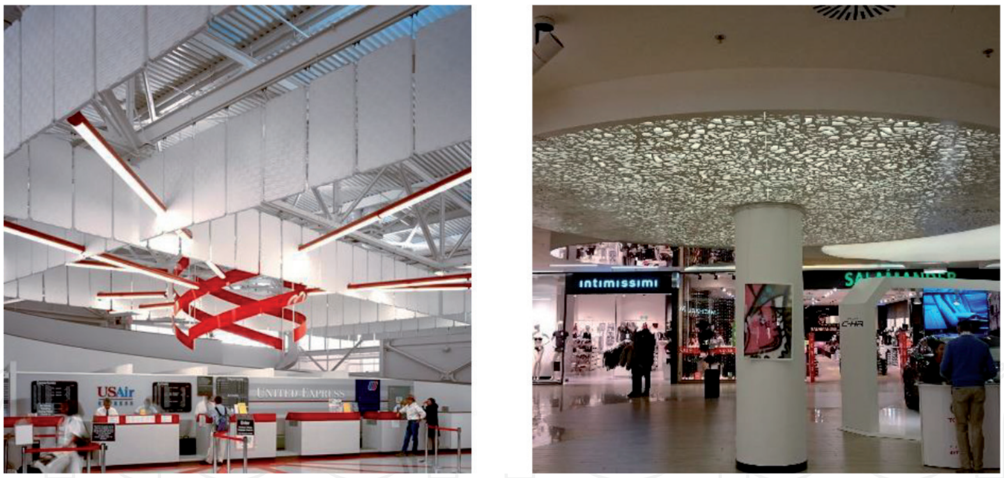

Figure 8.
Public announcement (main corridor in a mall where absorber patterns in the ceiling on the right and principal hall in airport where absorber baffles on the left).

quality to promote the privacy necessary. One of the human feelings is to feel shame from exposing private issues. Respecting and protecting these feelings are mandatory in designing such spaces. Such spaces could exist in buildings where other acoustical requirements are in question. Example of Doctor Room that needs privacy, during the clinic, and called for the quiet environment.

2.4.5 Spaces for public announcements

Airport, public malls, and governmental spaces for individual services are all spaces where public announcement occurs. The announcement of the flight number and timing requires a clearness in the speech to understand the announced information. Otherwise, the disruption and the distraction are the results. Similar results could happen in the public spaces as malls or governmental facilities (**Figure 8**). Acoustic design plays a different role in creating a masking background to clear the pronounced data.

3. Acoustical interior design elements

Interior acoustics support the well-being of the users. The design of the spaces that require a sound quality needs specific elements to embolden the acoustical quality. The interior acoustical elements involve and interlace with other acoustical fields. These elements start by the space layout, which should be architecturally created to the specific function to prevent any basic problems. Otherwise, the interior solutions could cover such deficiency. The selective materials are the essence of the interior acoustical design. The interior treatments, quality, and position play the main role in the excellence of the acoustical functionality. It is a pure interior design, although the architect and especially the architectural acoustician consider it, to a very recent date, architectural treatments. The acoustical sound systems come as the third element as it is the additional element to any acoustical interior, for specific targets. If the acoustical interior design reflects the user's function, the acoustical engineering solutions presented through the sound systems should have a specific objective.

The sound design, as a background, affects the users unconsciously. It could contribute to the psychological mood of the users. Human is productive while listening to his/her favorite music by 30%. The type of sound background—or the soundscape—contributes in the overall success of the interior functions. Slow music accelerates the blood circulation, therefore speeding up human functionality. On the other hand, the slow music depresses most of the time the human being. Soundscape, as a new psychological tool, bolsters in today interior design upgrading the overall interior purposes.

The interior acoustical design is a combination of these three important elements that create the interior spaces in excellence [7].

3.1 Interior acoustical layout

The architectural design affects deeply in the interior sound behavior. While the sound behavior follows the architectural layout, the architectural shape could lead to a successful acoustic or a harmful one. The architecture should support the acoustical design to enhance the functionality rather than create problems that need extra solutions. Domes, circular plan, parallel surfaces, and unproportioned spaces lead to several acoustical problems for the interior spaces. Solving these problems will over cost the interior, as the acoustical treatments are expensive as raw materials and as fire-resistant coatings [8].

3.1.1 Domes

Dome does reflect the sound to a specific point, creating a nonstop echo. Adding absorbers on the full surfaces of the dome will create a convenient sound layout for space. Suspending of a huge luminaire, designed for masking the echo, is a solution of cutting out the reflection but in condition to use an amount of absorbing materials within its design. Baffles are a different solution but, similar to the suspended luminaire, it will block the view of the dome and will create an additional different perception.

3.1.2 Circular plan

Circular plan is a challenge for the acoustical design perfection. Similar to some extent to the dome, straight surfaces of paneling would break the echo resulting from the circular perimeter. A mixture of balanced acoustical materiality scheme is the best solution, and the decision of the properties of the materials relates to the functional acoustical study of the specific interior [9].

3.1.3 Parallel surfaces

The interior surfaces should not have parallel surfaces, either as peripheral surfaces or as ceiling and flooring opposite to each other. The interior acoustical designer needs to break these parallelisms. The creation of acoustical interior treatments, diverse in quantities and properties, will solve this problem, although it is much expensive than having the spaces without such problems.

3.2 Interior acoustical treatments

The sound behavior in the interior spaces is the result of the interior treatments used. The quality and the properties of these materials share to some extent the success of the sound propagation within the space. The sound could be reflected, absorbed, diffused, or transmitted depending on the material physics (**Figure 9**). Materials used in the acoustical design are expensive as their majority are natural materials. Additionally, they need exclusive fire-resistant coating.

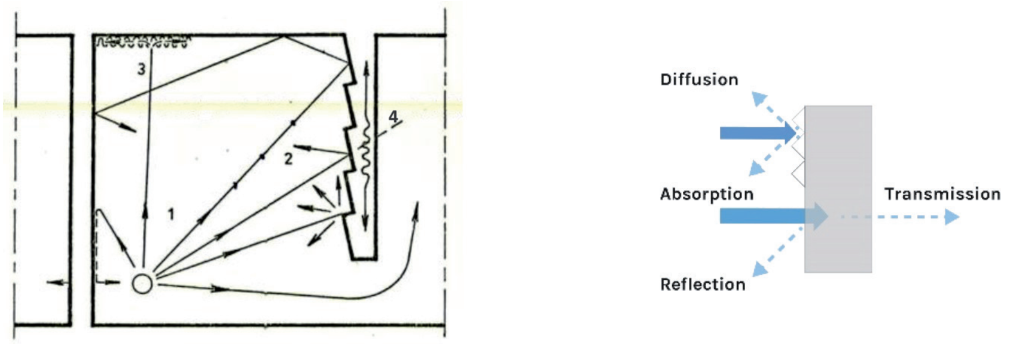

Figure 9.
Sound behavior in the enclosed spaces ((1) sound wave projected from the source, (2) sound wave reflected on the surface, (3) sound wave absorbed, and (4) sound wave transmitted).

3.2.1 Reflectors

Reflectors are hard solid materials that reflect the sound following the rule of reflection—angle of projection equals to angle of reflection but in the opposite side. Best reflectors are the ones made from natural hardwood with thickness limits of 5–15 cm (**Figure 10**). Oak, beech, mahogany, maple, walnut, and pine are all good selection. Ash wood is one of the best as it can easily bend which allows better coverage in favor of materiality limitations. Convex surfaces will scatter the sound waves allowing natural reinforcement for the unamplified voice without electrical sound systems while reducing the material surfaces.

3.2.2 Absorbers

Opposite to the reflectors, absorbers are soft, porous materials (**Figure 11**). Used to name the foams with different densities and thicknesses, a sandwich panel composed from a finished layer of fabric or soft natural perforated or slotted wood (with different perforation percentages), and the inside might be one or more of the following materials: rock wool, glass wool, or foam, based on its absorption coefficient "alpha". Heavy curtains exceed its dimensions seven times the length to work as absorbers.

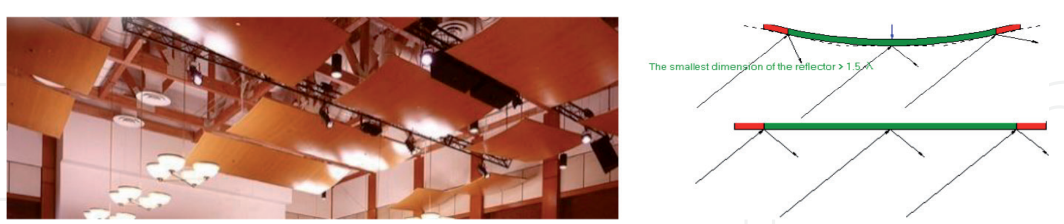

Figure 10.
Reflectors appearance in the interiors on the left and the difference of dimensions between the flat reflectors in comparison to the convex reflectors on the right.

Figure 11.
From left, perforated and slotted softwood, sandwich panels (fabrics coverage with glass wool, rock wool, or foam), and different densities of foam.

3.2.3 Diffusers

Diffusers are the type of treatments that deploy the sound wave in a way to keep it alive without reflecting it to a specific spot nor to absorb it (**Figure 12**). Diffusers are similar to the reflector properties **but** in altered shapes. They are hard solid materials full of angles and curves to diffuse the sound waves within the interior spaces.

3.2.4 Isolation materials

The isolation materials usually are used to prevent the transmission of the sound waves from space to another. Spaces could be enclosed or open, but the essential is to block their flows and thus avoid the noise transmissions. Isolation materials consist of high-density absorbing materials in addition to reflectors in a composition that supports, scientifically and structurally, the sound blockage. However, they are part of the structure of the building layout, yet the acoustical interior may interface to solve specific noise transmission and therefore be part of the design. Building materials are the rescue to solve such situation in the interior acoustical design phases.

3.3 Interior acoustical sound system

Electrical sound systems for the acoustical interior design are not useful, especially when the interior wall is acoustically designed. It has dedicated purposes when recording constituents play a role in the functional aspects. It is worth to mention that this section is an acoustical engineering field that serves the interior and its inhabitants directly. For the acoustical interior designer, the sound system exposure to three main questionings, the what, the why, and the how of the electrical sound system [10].

What are the sound system and its components? Why should we use the sound system? How to apply the sound system within ideal regulations?

3.3.1 Sound system components

What are the sound system and its components? The sound system encompasses three essential elements: the microphone, the loudspeakers, and the controlling devices (**Figure 13**). Microphones are diverse in shape, design, and specifications. Each serves a specific function. The self-switch, the controllable, and the standard normal are all options for the specific situation in the overall interior function and needs. Electrically spoken, the types of microphone differ based on the frequency response, internal circuitry, resistance to the moisture, diaphragm size, weight, and durability. Concerning the loudspeaker, it consists of main parts: the woofer for the low frequencies, twitter for the high frequencies, and the midrange. Finally, the control panel to amplify the sound based on the specific results is required [11].

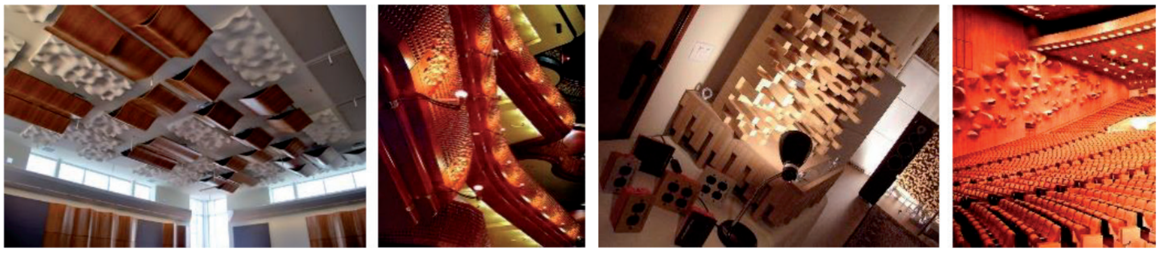

Figure 12.
Diffusers in different appearances of curves and angles, through the hard solid selection.

Figure 13.
Sound system components (microphone, loudspeakers, and control panel).

3.3.2 Sound system purposes

Why should we use the sound system? The sound behavior in the interior spaces is the result of the interior treatments used. The quality and the properties of these materials share to some extent the overall quality of the sound. Using the sound system is for recording the event (unrepeated or memorial event), for listening to recorded materials (like the cinema), and for the simultaneous translation. Except for these three purposes, the designer does not refer to the sound system since the interior which follows the standard setup will never necessitate such devices.

3.3.3 Sound system regulations

How to apply the sound system within ideal regulations? The sound system should follow strict regulations to ensure the quality level of the sound projected. Therefore, the strict regulations (**Figure 14**), once applied, will provide the best sound system results. The selection of sound system properties contributes to the overall design of these sound systems in the interior layout. The angles of the sound projections from the loudspeakers determine the numbers of speakers and their positions in the interiors.

The international meeting and event necessity are the simultaneous translation. In this case, the translation booths should be available by numbers equal to the six

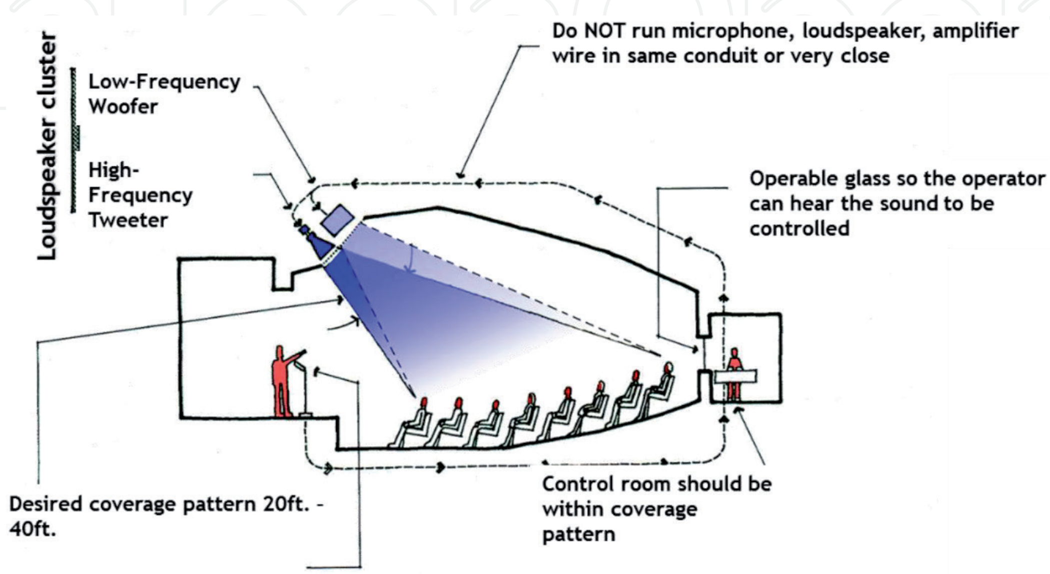

Figure 14.
Sound system regulations in a section layout [6].

official international languages. These booths should be enough in sizes to host, in each, two translators—each takes speech for 10 min. The visual field of these booths in the space must be clear to the main panel of discussion on the stage.

4. Interior acoustical design criterion

Interior acoustical design is a relatively new profession, yet the acoustics was one of the human concerns throughout history. By primitiveness, humans from the prehistorical dates, automatically, used their instinct to adjust their interaction fields in a way to reach the best paths of sound communications.

Lindsay's wheel of acoustics shows the selective area of the architectural interior design, but the related fields that share in some range their outcomes and make benefits to the interiors are many (highlighted in the wheel (**Figure 1**)).

Interior acoustical design is a field where mixes of discipline contribute to the sound excellence for the benefits of the users. Interior acoustical design involves the basics of physics as science relates the reflection, absorption data, the sound formula regarding the reverberation time, the physical measurements of the materials based on the coefficient of absorption (alpha $\bar{\alpha}$), the space volume, and the sound frequencies. All these inputs enabled the creation of the new interior acoustical wheel (**Figure 15**) [12].

Interior acoustical design implicates in parallel the artistic perception of the material selection, the material patterning, and the material color schemes. Therefore, the interior acoustical design is deliberated, as science and art, through the following points:

- The **classification of functional interior** permits the selection of the design paths regarding materiality schemes that support the interior function in favor of the users. The five different space functionality classifications are speech intelligibility, quiet interior, music enhancements, privacy needs, and public announcements.

- The **soundscape** plays a major role in the psychology scheme of the space as much it affects the users in unconscious ways.

- The interior acoustical space needs hard efforts to prevent the weakness of the **architectural layout** from the architectural perceptions, the domes, the

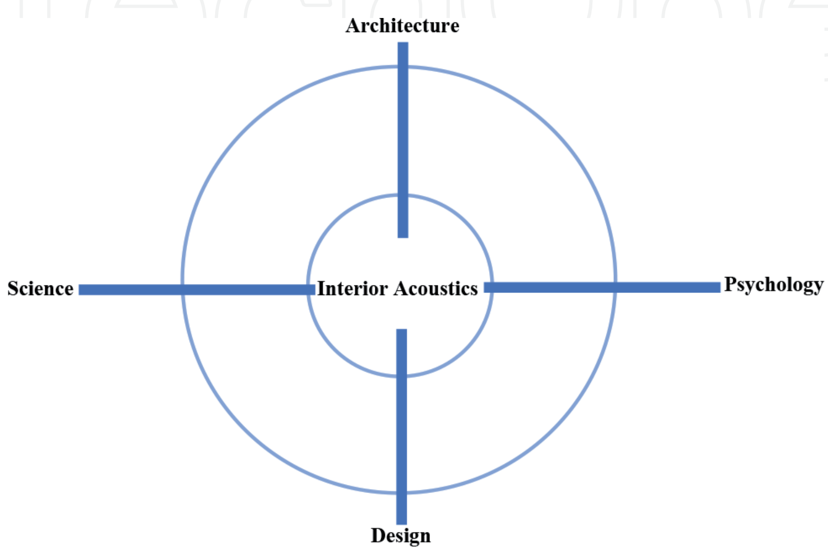

Figure 15.
Interior acoustical design wheel.

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parallel surfaces, the unproportioned spaces, and the circular plan's to reach an appropriate acoustical interior design.

- The interior acoustical design—or **room acoustics**—depends on the quality of the **material properties** and their **positions** in the interior.
- The interior acoustical material classifications are reflectors, absorbers, and diffusers.
- **Reflectors** are hard solid materials, where the designer can use simple formulas to determine their position (**Figure 16**), where "A" is the projected ray of sound, "B" is the reflected ray of the sound, and "C" is the direct ray of the sound.
- **Absorbers** are soft porous materials, where the coefficient of absorption alpha ($\bar{\alpha}$) specifies their level of absorption. The material is absorber if $\bar{\alpha}$ = 0.6–1 (**Figure 17**). Absorbers are composite materials (sandwich panels).
- **Diffusers** are hard solid materials full of curves or hard edges (angles).
- Isolation materials are within the architect responsibility, yet the interior designer could refer to them when needed.
- The **sound system** is designed by the electrical engineers, yet it is part of the acoustical interior layout upon strict guideline of uses. The three functional parameters of the electrical sound systems are recording the events, listening

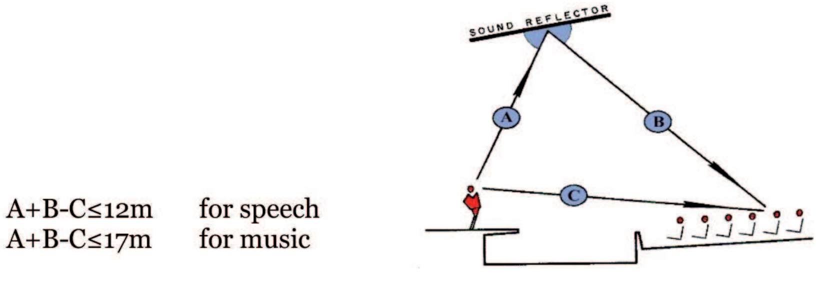

Figure 16.
Reflection position formulas [13].

Material	Frequency (Hz)*					
	125	250	500	1.000	2.000	4.000
Acoustic Panels	0.15	0.3	0.75	0.85	0.75	0.4
Brick	0.024	0.024	0.03	0.04	0.05	0.07
Carpet	0.05	0.1	0.2	0.25	0.3	0.35
Curtains	0.05	0.12	0.15	0.27	0.37	0.5
4" Rockwool	0.38	0.89	0.96	0.98	0.81	0.87
Wood Floor (Joists)	0.15	0.2	0.1	0.1	0.1	0.05
Glass	0.03	0.03	0.03	0.03	0.02	0.02
Seated Person	0.18	0.4	0.46	0.46	0.5	0.46
Plasterboard	0.3	0.3	0.1	0.1	0.04	0.02
Plywood on 2" Batten	0.35	0.25	0.2	0.15	0.05	0.05
¾" Wood Panel	0.1	0.11	0.1	0.08	0.08	0.11

*Note: A ($\bar{\alpha}$) coefficient of 1.0 means 100% Absorption, such as an open window, while 0.0 means 100% Reflection, such as glass. All figures are given for one square meter of materials.

Figure 17.
Alpha chart to standard frequencies.

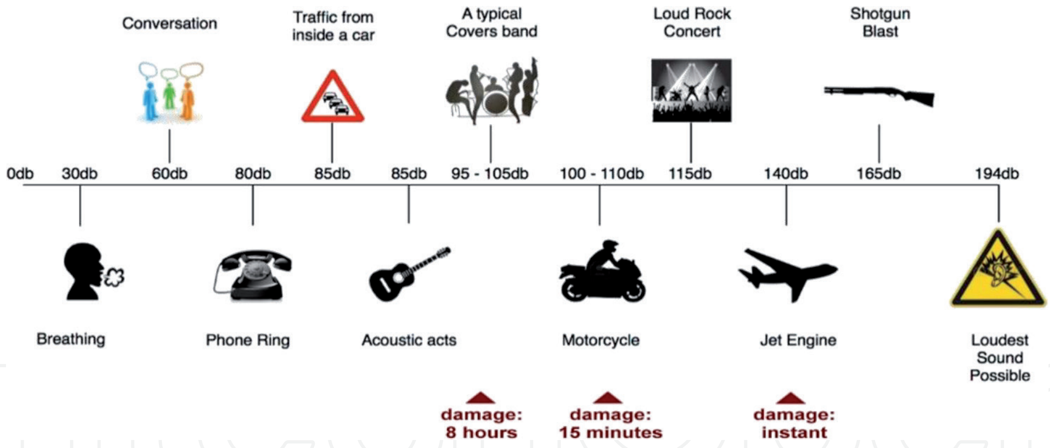

Figure 18.
Sound level chart to the normal daily life, where the hearing damages are indicated.

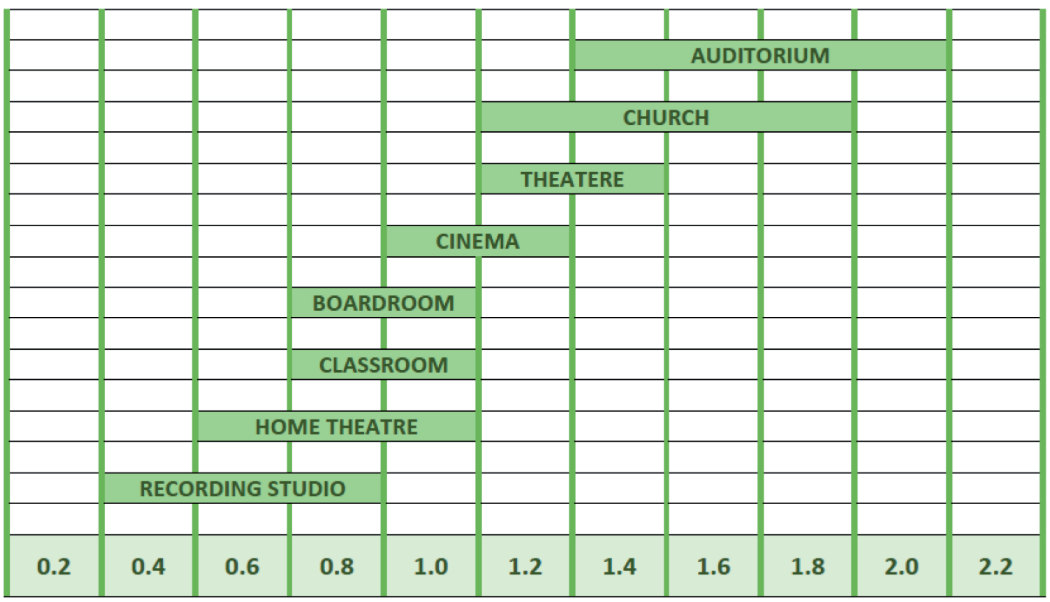

Figure 19.
Reverberation time (RT) measured in seconds for specific functions.

to recorded materials, and simultaneous translation. The sound system should follow the rigor layout for the benefits of the output sounds.

- The **sound level** (measured in decibel—"dB") (**Figure 18**) appropriate to the function is standard, and the interior acoustical designer needs to follow the mathematical steps (using Sabine or Earing Formulas) to reach the convenient reverberation time (RT) (**Figure 19**). These steps and formulas are part of the mechanical engineering field.

- The interior acoustical design is a combination of science, architecture, psychology, and design that contribute in interlacing paths to reach the sound excellence for the wellness of the human being.

5. Conclusion

The acoustics from interior designer perspective reach the end. The following indices could conclude the main features of discussion, already detailed within this chapter:

- Acoustics dates from the prehistorical eras, where the human considered it a vital component of the daily life, to sustain the communication.
- The uses of the architectural layout and the interior components were the tools to apply a good acoustical environment, using the science, within the historical periods.
- Interior acoustic design needs a clear classification of functional necessities to reach a successful synthesis that suits the end users of the spaces.
- The interior acoustical success relies on the quality and the locus of the materials used within the space upon stricken regulations.
- The material quality determines either it is a reflector, absorber, or diffuser.
- Reflectors are hard, rigid, and thick materials.
- Absorbers are soft and porous, and, usually, they are in the form of "sandwich panels."
- Diffusers are similar to the reflectors but never in plane surfaces, only if full of curves or angles.
- The coefficient of absorption (alpha $\bar{\alpha}$) factor permits to apportion the material scheme within the interior. Alpha differs upon the level frequencies. When overall alpha magnitude reaches the round of "1," it means the material is absorber, and when reaching the round of "zero," it means the material is reflector.
- Sound systems are used for only archetypical purposes and should follow the confine regulations.
- Soundscape is an element to consider effectively, as it affects the human psychological within the interior layout.

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Nomenclature

Reflectors	are hard solid materials to reflect the sound waves
Absorbers	are soft porous materials to absorb the exceed sound
Diffusers	are hard sold materials full of edges to scatter the sound
dB	decibel: measurement unit of the sound level. "deci" logarithm unit and "Bel" in honoring Alexander Graham Bel, the founder of the sound science
RT	Reverberation time is the lifetime of the sound until it becomes mute and measured by seconds
Hz	hertz, the measurement unit of the sound frequencies
Woofer	the part in any loudspeaker responsible of the low frequencies
Tweeter	the part in any loudspeaker responsible of the high frequencies

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