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The Auditorium Chair Standardisation. Evolution of the Seating and the Anthropometric Scale of the Auditorium

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Abstract
The performance halls are categorised based on their use and their size, meaning, the type of performance that they can host and the number of spectators that can be accommodated.

The key element that determines the size of a venue is the anthropometric coefficient. Since the emergence of the proscenium scene type, the dimensions of the auditorium have changed many times, both in size and in proportions, affecting the overall design of the space. Particularly, from the moment that the seat of the audience became a product, it acquired standard dimensions that met both house specifications and human scale.

The human size determines the dimensions of the seat and thus the required space of the spectators and the size of the room. As the stature of the "average" person has increased, the requirements for auditorium seating have changed. The dimension of the auditorium chair has considerably increased over the last 50 years, as modern lifestyles and modern eating habits have contributed to the increase of the average person's size, redefining design and sizes of several products. The aim of this paper is to identify and present the relation between the auditorium's chair size with the human size evolution, as well as specifications that the performance hall requires.

Keywords
human size, theatre design, theatre chair, auditorium seat, auditorium size

1. Introduction

Every performance space is defined by the interaction of two groups: the stage area and the auditorium. The stage area's size and specifications are determined by the hosting performance and the necessary technical requirements, while the auditorium's space main goal is to host an audience with the best possible conditions of attendance.

The seating area has taken many forms and shapes from the ancient open theatres marble benches till today's hi-tech chairs of theatres and cinema houses; but the purpose remains almost the same: to provide for the audience the best possible view to the stage - screen, along with a certain comfort. Since it's transformation to a mass production object, two dynamic factors are defining it's standardisation: the size and the house-specifications. The size of the chair is in direct relation with the human measurements while the specifications are depending both on the type of the auditorium that the chair addresses to and on the level of comfort it is called to provide.

2. From Benches to Individual Seating Adaptation

The inauguration of the modern theatre period it is considered to be the construction of "Teatro Olimpico" in Vicenza of 1580, along with "Teatro Farnese" in Parma of 1618 [1]; the theatre seating arrangement in both cases though was in direct relation with the roman theatres, formed by marble or

wooden benches circulating by 180 degrees an empty flat area at the extension of the stage, an area that later will form the auditorium. The spectators were seating along the benches while the empty area was used serving as a performing space or additional seating area with movable wooden structures.

In late 16th century in Spanish "Corrales" and mid-17th "Globe Theatre" era in England, the seating arrangement depended on the social background of the spectators. As the inner courtyard of the hostels defined and served as a theatre house, the only seats for the upper class were placed on the balconies facing the stage, while the lower social classes were gathered at the open roof yard without any option of seating [2]. Between 1640 and 1790, the Baroques Golden Theatre, the form of the theatre reaches it's final proscenium stage were the house is a horseshoe shaped, with a slightly inclined auditorium encircled by at least four box hosting balconies. All the Italian and French typical theatres of the period follows the same typology for the house seating arrangement: the central or the two boxes of the first balcony at each side of the proscenium were dedicated to the royal family, while all the other boxes to the noble of the society. All the boxes where equipped with handmade decorative chairs or sofa - style linear seating arrangement [3]. At the same time the mid class was seating on wooden benches at the auditorium, while the lower class and the servants were shearing the "paradise", the top of all the balconies without any seating equipment at all [4].

In 1794, four and a half years after the French Revolution, a bill of the French Committee of Public Education indicates the introduction of the social seating arrangement in theatres, meaning the abolishment of the royal and upper class seating zones in the auditorium. Several theatres started to renovate accordingly in order to form a unique space, but the 1795 events cancelled all the social changes in theatres; the "seating revolution" lasted until 1807 when Napoleon re-introduced the imperial throne at the central box of the first theatre balcony [5]. In 1847 at the "Royal Theatre" of London, the royal box was still at the first balcony over the left side of the proscenium, while the rest of the boxes equipped with handmade decorative chairs were addressed to the aristocracy. The crucial difference with the prior theatres is that the mid class spectators were able to seat on benches in a church like formation on the flat surface of the auditorium [6].

A first step towards the standardisation of the auditorium seat can be seen in 1876 when Oscar Brückwald designed the new Bayreuth Theatre, the first theatre without boxes and with a unified space as a spectator's area [7]. As a result, a one - seat - type was introduced to the seating area, a type that was addressed to all the spectators. From that point on the ticket price was depended on the location of the seat in the auditorium space and not on the "seat type" regarding the social background. In general nineteenth - century theatre seating is characterised by the introduction of prefabricated individual seating chairs [8] showing the way to the standardisation of the seat's dimensions and row arrangement in the auditorium. Theatre seating from 19th century forward is a mass - produced commercial product supplied by manufacturers following certain specifications.

3. Auditorium Seat Specifications

The definition of the auditorium chair is a result of decisions on standard values of various chair's specifications. These specifications are defined mainly by the chair's manufacturer considering the type of the performance space that their product addresses to. As a result specifications are referring to four general performance spaces:

- theatre - auditorium chairs that also includes drama, dance and opera,
- concert hall,
- cinema - home cinema and
- conference hall - multi purpose space - educational facilities.

Specifications may be common among different types of performance spaces, but in the majority of the cases are referring to the special architectural character of each project, creating a list of characteristics that referring from technical details to aesthetic parameters:

- quality of the chair - product in terms of durability and maintenance
- materials of the main frame in accordance with ISO
- type and quality of fabric in accordance with fire regulations
- colour and colour combinations of the fabric and the main body

- geometry in terms of retractable seat or inclined back
- additional components such as writing table or cup holder
- mounting methods in terms of number of legs and removable or not
- connection ability of the leg's column with the MEP facilities of the house
- acoustic behaviour of the chair - sound absorption value and area when the chair is in use or not.
- connection with the next chair according to the row layout.

Above all auditorium chair manufactures project the aspect of comfort as main part of chair's specifications.

4. Seat's Comfort Relativity

Although Peter Brook mentioned that "the least important thing in the theatre is comfort" [9], the design aim of an individual auditorium seat is to provide an appropriate level of comfort during the performance.

But "comfort" is a relative factor that depends on various aspects. The sense of comfort relies both on the designed object and on the user's profile; the case of the auditorium seat can be seen in:

1. the seat's physical characteristics such as dimensions, height and inclination, leg room and material,
2. the user's profile where the tolerance of comfort levels is vary between
   2.1. age, as young spectators can tolerate simple seating more than older age groups,
   2.2. nationality, as the average human measures differs among nations,
   2.3. generation, as the average measures of people is getting bigger,
3. the type of performance attended, as the spectators that are attending concerts of classical music expect a level of comfort higher than those at a drama performance [10], in the same way that the standard cinema chair with the cup holders and the wide personal space is completely different than the live performance drama seat that provides the adequate awareness and the level of alert at the specific audience.

Every country has developed several regulations concerning the size of theatre chair, more or less according to the mentioned factors.

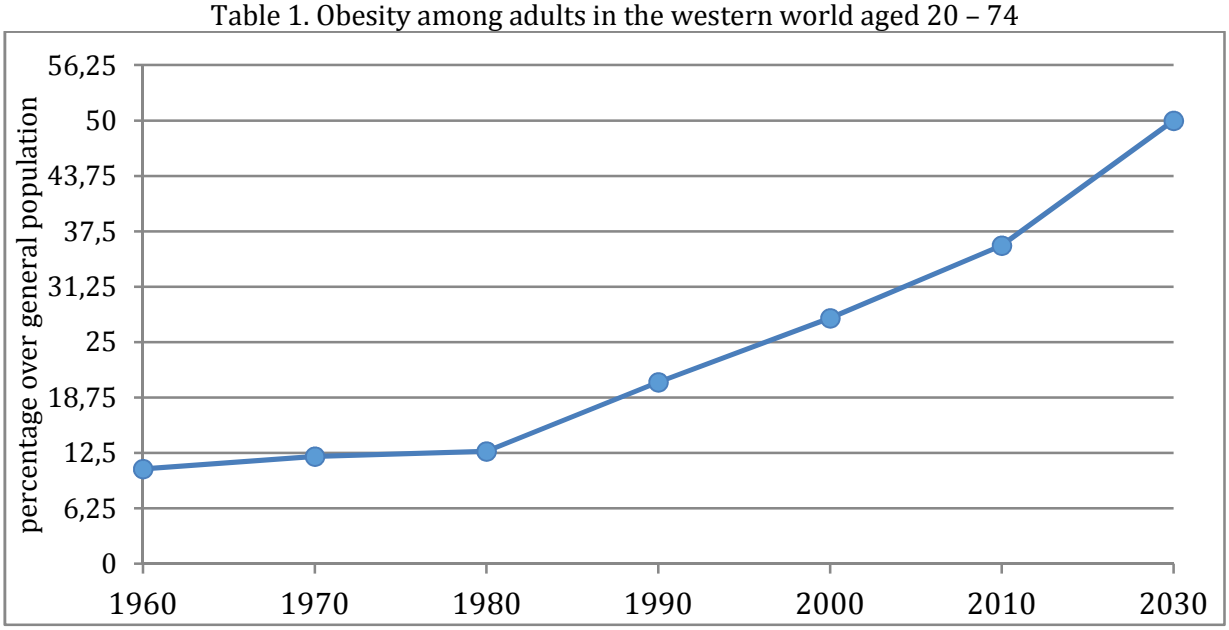
5. Seating Dimensions

In most of the EU countries, the theatre type chair width dimension is between 450mm and 580mm, while in USA is 482.6 mm to 584.2 mm (19'' - 23''). Of course dimensions varies between along countries, thought the fact remains that those measurements are not standard but rather subject of a decision at the design stage, and then in coordination with the variety of chairs provided by the manufacturer [11], as long as they don't violate the fire escape regulations.

During the past 100 years the average seat width has grown from 45 mm to 56 mm, a grow of 12.7% that is related to a growing human size as "Theatre Projects Consultants" mention [12]. Since the very first open performance spaces, the size of the seating area has changed, indicating that people are getting bigger in size, affecting the design of the auditorium seating. According to the WHO statistics since 1980, the obesity and overweight population has doubled worldwide [13]. In 1975, 105 million people were overweight, while 641 million in 2014, a rise of 610%. Moreover, 20% of the global population and 50% of the population of the western world will be overweight by 2025, mainly due to bad nutrition habits and lack of exercise (Table 1).

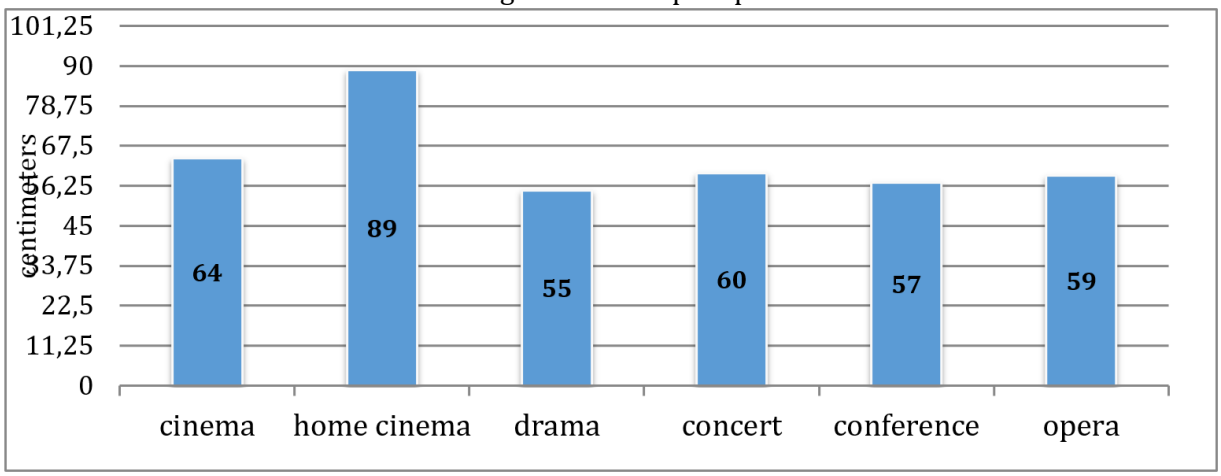
As a result the average "standard" width in auditorium chair specification is getting bigger with an accelerate pace. But human's size is not the only thing that affects chair's dimensions. Minimum and maximum standard chair sizes are provided by rather tolerant recommendations of institutions and legislations. Those dimensions are not obligatory as they answer mostly to the theatre operators concerns to provide more comfort to the theatre goers due to the competition from a widening array of entertainment options. Additional services varying from food and drink to wi-fi access during the performance can be seen, adding millimetres at the average size of the individual chair (Tables 2 & 3). As a result auditorium measurements are getting bigger; in other words as the standard chair is getting bigger, a bigger space is needed to accommodate the same amount of spectators as before.

Table 1. Obesity among adults in the western world aged 20 – 74



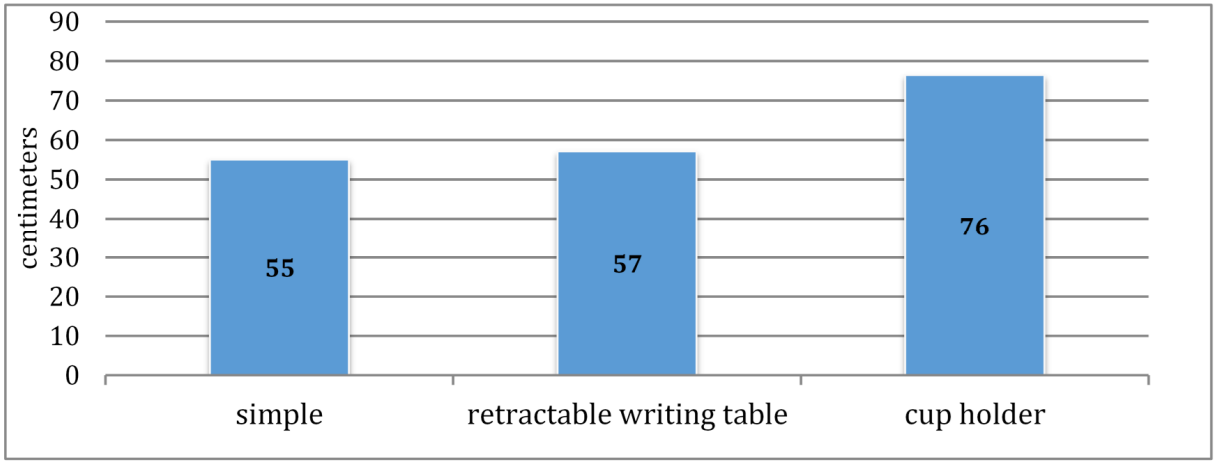
(source: author's calculations based on NHANES data & Eurostat)

Table 2. Average seat width per space function



(source: author's search based on manufactures and builded spaces in EU. Sample range 40 values per category)

Table 3. Average seat width with additional components



(source: author's search based on manufactures. Sample range 40 items per category)

6. Auditorium Measurements

The size of the auditoriums is calculated on the base of it's capacity in spectators, directly linked to the stage measurements and hosted performing art [14]. As people are getting bigger so does the auditorium chair, affecting the auditorium size. As mentioned the average chair measurements it's not a standard value but a design decision to be taken. Meanwhile legislations are more strict and absolute defining the minimum clearance at the accesses at the auditorium area, both in the distributing corridors and the seat back to back distance, due to fire escape regulations.

The row spacing is a relative value to the chair measurements, and it has grown the past 100 years 50%, affecting seating density, giving an average pace of 5cm every 10 years. Today's legislations suggest a row space from minimum 90cm, as long as a minimum 30cm passage clearance is achieved with the seat in the lowest position (Fig. 1), meaning that in 2030 if the pace continues there will be one row less on every today's seventeen.

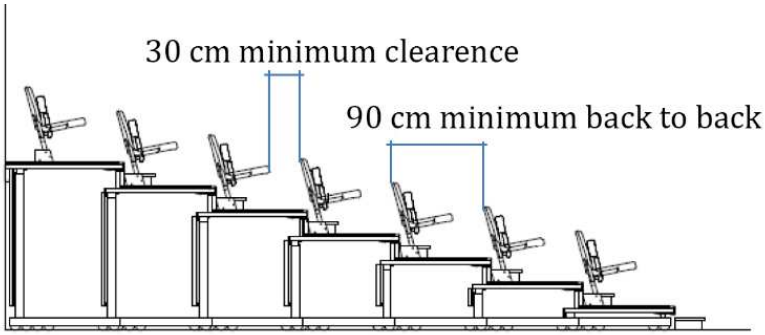
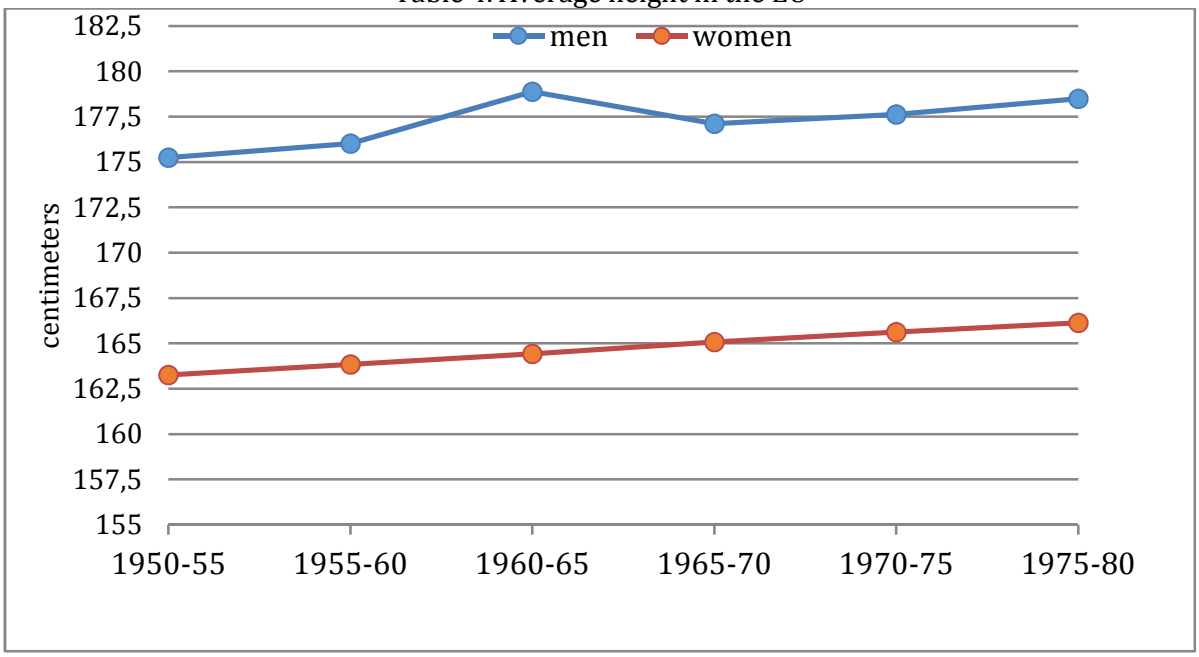


Fig. 1. Minimum passage clearance and minimum back to back space according to most of the today's legislations

As the chair and clearance area is increasing, the density and the seating capacity is decreasing fitting less chairs in the same area as previous. New auditoria need more space to fit the same capacity, renovations of old performance spaces fit less audience making the financial decisions harder.

People are not only getting fatter, but bigger in terms of height as the average height of both men and women is increasing [15] (Table 4).

Table 4. Average height in the EU



(source: author's calculations based on Jaume Garcia and Climent Quintana-Domeque (2007), *The Evolution of Adult Height in Europe: A Brief Note*)

Since the 50s the average human height has increased nearly 10cm updating the anthropometric scale. As a result two things are affected: the height of the chair's back and the optical tolerance of the back row, and the optical design of the house, meaning the row height, the inclination of the house floor providing the ability from every seat to see the stage, as illustrated below.

"C" factor, the eye level from the ground is directly related to average human heigh, affecting the "y" factor meaning the row height, and the "Σα" factor the optical tolerance of the back row. In addition "y" factor is in direct relation to "d" factor meaning the back to back chair distance, a value that is affected by chair's and human's size as well, redefining the curve describing the auditorium's floor (Fig. 2).

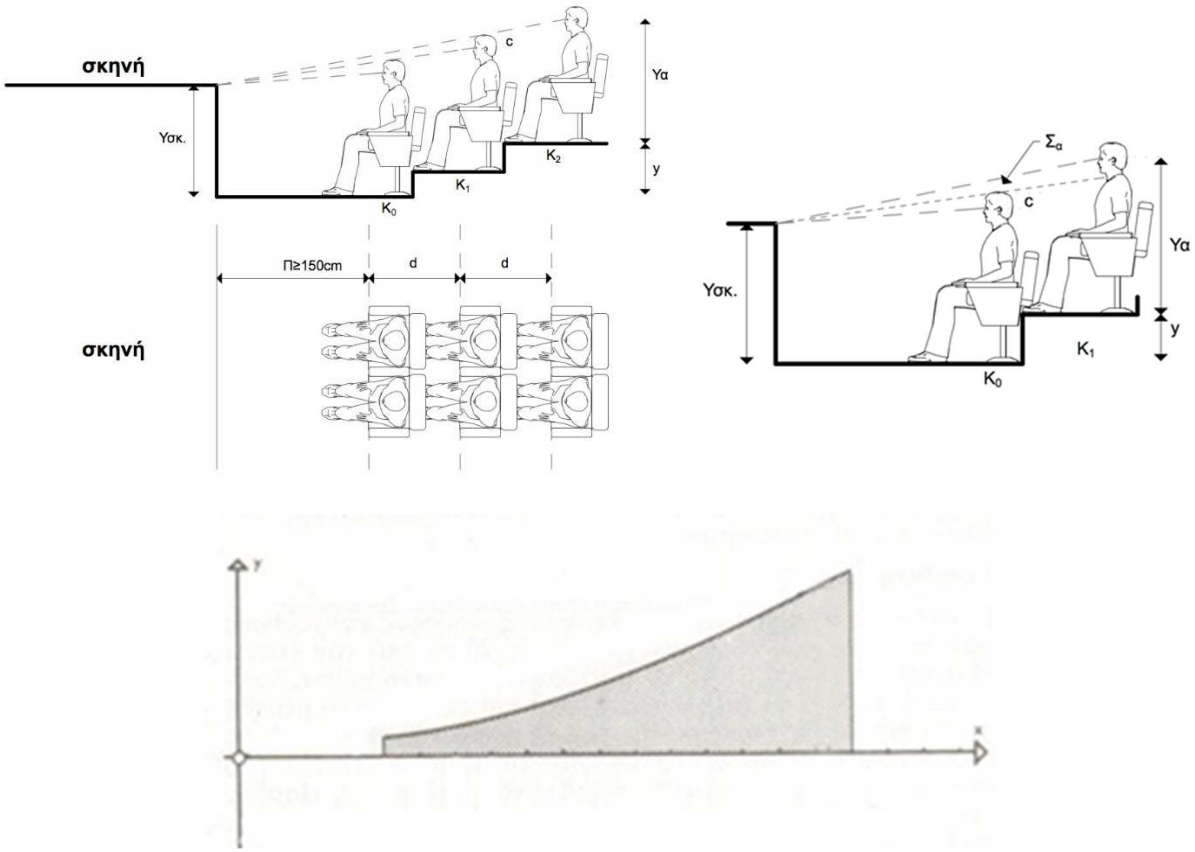


Fig. 2. Gellinek's function graphical representation of the inclination curve of the auditorium in relation to design values

In other words Gellinek's function: $y_n(Y_{\sigma\kappa}) = [c/d \cdot 2.31\log[(\Pi + d_n)^2/\pi] + (\Upsilon\alpha + c)(\Pi + d_n)/\Pi - c] + \Upsilon_{\sigma\kappa}$ that relates the "d" distance (back to back chair distance) and "y" factor (row height) is depended on people's nutrition habits.

7. Conclusions

Since the minimum or maximum size is not an obligation but a recommendation there are many variations in sizes, related both to human's size and to the specifications needed for the performance space. The evolution of the average auditorium chair dimensions shows a growth regarding the human aspect that is related to the hight and augmented predictions of obesity and overweight population, and regarding the space's specification the feeling of comfort.

The chair's size is growing as humans are getting bigger, but it has a ceiling. The seat dimensions will keep on rising following the human scale, but up to a certain point balanced on a new average size.

On the other hand, the comfort feeling is a factor that is depending on both to measurable values related again to human nature, and technological innovation applied on. As the technology has the trend to get smaller, the pace of size's growth is decreasing.

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