SEATING RATIO OF PRIVATELY OWNED PUBLIC SPACES

Effects on users' perceptions, impressions, and judgment of suitability for different activities

PROPORÇÃO DE ASSENTOS EM ESPAÇOS DE USO PÚBLICO

Efeitos na percepção, impressão e julgamento da adequação para diferentes atividades pelo usuário

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Abstract

Parametric design requires an understanding of the effects the manipulation of a given parameter will have on users. However, there is still little research on the relationship between public spaces' physical elements and their effects on users, so urban squares are designed based on the designer's aesthetical aspirations and other unresearched factors. This study used immersive virtual environments and allowed participants to move around freely in the environment to investigate the effects of two parameters: seating ratio and environment scale, across 23 different evaluation scales. Stimuli used controlled for other variables, and results showed that increasing seating ratio past a certain point worsens users' perceptions and impressions of the environment, providing evidence for policymakers' guidelines regarding the amount of seating to install in public squares with implications for the design of privately owned public spaces as well.

Keywords: seating ratio, privately owned public space, plaza design, environment scale, immersive virtual environments.

Resumo

O Desenho Paramétrico exige uma compreensão do efeito que a manipulação de uma determinada variável terá nos usuários. Entretanto, ainda há pouca pesquisa a respeito da relação entre os elementos físicos que compõe um espaço público e o efeito que sua manipulação tem nos usuários, de forma que os espaços públicos são projetados com base em aspirações estéticas e outros fatores não investigados. Este estudo utilizou ambientes virtuais imersivos e permitiu a livre movimentação dos participantes dentro dos ambientes para investigar os efeitos de dois parâmetros: a proporção de assentos e a escala do ambiente em 23 diferentes escalas de avaliação. Os estímulos adotados controlaram para outras variáveis e os resultados mostram que aumentando a proporção de assentos além de um determinado ponto afeta negativamente a percepção e impressão do ambiente, provendo evidência para legisladores estabelecerem diretrizes de quantificação de assentos, além de implicações diretas no desenho de espaços de uso público.

Palavras-chave: proporção de assentos, espaços de uso público, desenho urbano, escala do espaço, ambientes virtuais imersivos.

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Introduction

Public spaces permeate every aspect of our lives. They connect all places where human activities take place and provide a stage for social life. In public spaces, we consume information and goods, experience nature, meet others, and socialize (LEFEBVRE, 1991). Given these essential roles, public spaces should provide opportunities for discussion, encounters, and deliberations while allowing for different world views (NÉMETH, 2009).

Since the 1980s, as our cities continue to become more crowded and compact, responsibility for the provision of public spaces for social activities (e.g., plazas, arcades, city squares, parks) has shifted from the government to the private sphere, primarily through floor area ratio (FAR) exchanges (BANERJEE, 2001; DE MAGALHÃES; FREIRE TRIGO, 2017; LANGSTRAAT; VAN MELIK, 2013; NÉMETH, 2009). Most of the spaces commonly perceived as public in city centers are privately owned public spaces (POPS), meaning that the design choices about the spaces' usage, equipment provision, finishes, and spatial configuration have been transferred from the public to the private sphere.

City governments have tried to establish directives to ensure a minimum quality to public spaces, the most notorious being the New York City directives that emerged from a study commissioned to William H. Whyte in the 1970s. Since then, most metropolises worldwide have adopted some version of FAR exchange policies within their design directives. While these directives specify minimum requirements, there is still much to learn about how the environments meeting those requirements affect users and their behavior and interactions in the space.

The perception of the built environment is affected by a great many variables: shape, form, composition, structural elements, enclosure, usage, climate, culture, amongst others, and the effects of each variable on users' perceptions are difficult to identify, let alone the effects of their interactions. The practical result of this complexity is that, in the absence of data, designers adopt personal assumptions about what design option produces what effects on users, with little knowledge as to whether those assumptions are useful heuristics or personal biases.

This paper focuses on one fundamental element present in nearly every public space and is often regulated by city governments to ensure POPS' quality: seating. While increasing the number of seats in a public setting allows more users to prolong their stay and develop social activities (GEHL, 2011), seating also takes physical space in a plaza. At some point, the amount of seating in a public space will start to be perceived as clutter instead of desirable urban furniture, and this will negatively affect users' perceptions of the environment, hindering instead of improving their social activities. This research was built on a previous study (AVALONE NETO *et al.*, 2017) to assess what floor area ratio seating stop being desirable and negatively affect users' perceptions, impressions of the environment, and perceived environment suitability for developing some specific activities.

Background

Public spaces are essential for social life since it allows people to confront, interact and accept others from different backgrounds, experiences, means, cultures, and values (LEFEBVRE, 1991; ROGERS, 1998; YOUNG, 2003). Historically, governments have provided public space as a public good either as an infra-structure necessity, such as streets and sidewalks, or as amenities such as parks, plazas, squares, or playgrounds.

With city densification and preoccupations with public health and city sanitation, cities have limited the city lot's occupancy ratio, allowing for public pockets to be formed in front of high-rise buildings. Once surrounded and with restricted access, those areas have been expanded and transformed into urban plazas through FAR exchange policies (BANERJEE, 2001; NÉMETH, 2009).

The policy of exchanging area on the ground floor for the right to build more floor area has proven to be a valuable tool for city governments to provide public space in highly dense city centers (WHYTE, 1980). As the city densifies and lots are redeveloped, the city can provide new public spaces on the ground floor for its inhabitants. Since space is the most scarce resource in dense city centers, this development tool has been adopted worldwide.

However, a problem arises with the separations between the public and private sphere: the finished plaza should be public, although it is built on private land. The cost of building the public space (amenities, materials, equipment, landscaping) and maintenance is the landowner's responsibility (NÉMETH, 2009; WHYTE, 1980). This separation of duties and ownership reduces city governments' incentives to provide high-quality, fully public spaces such as parks, city squares, or urban plazas since they require large areas in the city center and have high implementation and maintenance costs. On the other hand, the landowner has an incentive to create public spaces around their building because they will receive the right to build a far larger area vertically and to produce the least expensive and maintenance-free public space as possible since he will bear the implementation and maintenance costs.

The proponents of such laws do not ignore these perverse incentives. In 1975 the city of NY already enacted amendments to its zoning resolution that provided FAR exchanges to ensure that public spaces were amenable. They established guidelines for seating, tree planting, retail frontage, lighting, circulation and access, food facilities, and maintenance (WHYTE, 1980). Those guidelines establish the minimum requirements for the public space to be amenable, but it does not consider the relationship between each element's amount and its improvement to public space quality.

The example of NYC is given because it was amongst the first cities to implement FAR exchange legislation, which later served as an example or basis for countless cities worldwide. Today, the implementation of POPS is ubiquitous and has become the standard of public space provision in city centers. The incentives to landowners are still the same: fulfillment of the cities requirements at the lowest implementation and maintenance cost, control of the space usage, and establishing a relationship between the plaza's identity, the building, and its entrance.

Nowadays, to improve cities' public spaces, it is necessary to improve POPS design since they account for most newly created public spaces (NÉMETH, 2009). That can only be achieved if designers have a clear understanding of how manipulating different design elements translate into users' perceptions and impressions of the public environment and how that can lead to extended stays and space patronage since the designer will have to justify design costs as expected behaviors.

There is a wide range of research focused on the environment's effects on user perception and behavior. The most recurrent is the effect of trees which have been found to affect business districts perceptions, patronage, and product pricing in a positive way (WOLF, 2005), reduce assault, battery, robbery, and narcotics crime rates in park settings (SCHUSLER *et al.*, 2018) and positively affect cleanliness, worth of stay and willingness to visit or revisit urban squares and plazas (RAŠKOVIĆ; DECKER, 2015).

Most research, however, provides little information that may be readily applied to public space design. While most of the research relates some design element, such as seats, trees, food trucks, or statues, to perception, that is mainly done through the measurement of preference, resulting in binary results showing an effect due to the presence or absence of said element. Binary results, unfortunately, do not educate designers on how to apply that knowledge to design.

Some research that further explored the manipulation of design elements is noteworthy such as Jiang et al. (2015), which related tree canopy density and preference, finding a relation between the number of trees and increase in preference, with most improvement occurring between 0 and 10% of tree density as measured in site plan with diminishing effects as density increases up to 60%.

As stated earlier, there are numerous variables to consider, and any study cannot explore them all. This study will focus on public space seating and overall public space size to contribute to a body of knowledge about design elements and the effects that may be achieved through their manipulation in public space design.

Seats are a structural component of public spaces design and an essential element for a stay to occur. Prolonged activities such as resting, eating, drinking, staying, and conversing require or are facilitated by seats (GEHL, 2011). While all sittable surfaces in a public space may be interpreted as seats, they are commonly classified into primary (e.g., chairs, benches, stools) and secondary seats (e.g., stairs, steps, planter walls), with primary seats being generally preferred and secondary seats filling the demand for extra seating when there is high demand (GEHL, 2011).

Seats are selected considering other occupants (HALL, 1990; WHYTE, 1980), spatial distribution (GEHL, 2011), seat characteristics (AVALONE NETO; MUNAKATA, 2015; GEHL, 2011), and based on the activity intended (AVALONE NETO; MUNAKATA, 2015; HAYASHI; OHNO, 1995; LI *et al.*, 2009; OHNO *et al.*, 2006).

The mere presence of seats can improve visitability (WHYTE, 1980), and this effect is amplified by other elements such as sculptures (ABDULKARIM; NASAR, 2013). Mehta (2007) finds that seats are crucial for street activity, with commercial seating alone accounting for 11.5% of his sample variance.

Whyte (1980) suggested that POPS should have a linear measure of 30cm of bench for each 2.80m^2 of the plaza area, provided that the bench had a minimum depth of 40cm. In other words, he suggested that 4.37% of the plaza area ratio should be of sittable area. However, this number is based on observations with no reported statistical analysis or relation between seats and users' perception of the environment.

Avalone Neto et al. (2017) established that increasing seating ratio improves perception and impressions of the environment and perceived suitability for different activities. It was found that increasing the seating ratio from 1% to 5% improved perceived suitability for stay, eat/drink, rest, and read activities while reducing perceived suitability for wait activity. It also improved impressions of environment appeal, interest, atmosphere, liveliness, diversity, perception of view, greenery amount, greenery placement, seat placement, and seat design. Users in environments with seats at 5% were willing to pay more for a cup of coffee and stay longer than in environments with only a 1% seating ratio.

Regarding space size, Talbot and Kaplan (1986) found a correlation between urban open area preference and environment size, which was confirmed in a subsequent study (TALBOT; BARDWELL; KAPLAN, 1987) with the exception that spaces too small (such as one-meter strip front yards) or too large (huge straps of lawn with little to no development) were negatively perceived. Kaplan (1980) suggested that a space with many smaller regions is preferred over one large space.

The perception of the environment's size depends not only on the place's floor area but also on its surroundings. An environment with the same floor area may be surrounded by high-rise buildings or by six-lane highways altering the environments perceived, although not its objective size. Since POPS are located in urban areas, it is essential to factor this in users' perception, which is most commonly done using three evaluation scales: enclosure, spaciousness, and oppression.

Enclosure refers to physical barriers present in the surroundings that block vision or motion (STAMPS, 2001).

Spaciousness, or openness, measures the feeling of how open an environment is perceived. It is positively correlated with sheer floor area (STAMPS, 2007), negatively correlated with the percentage of floor area obstructed (IMAMOGLU, 2000; STAMPS, 2007; STAMPS; KRISHNAN, 2006) and boundary height (COETERIER, 1994). Oppression is generally understood as the opposite of spaciousness or openness.

All three scales are closely related to environment size, enclosure type, and enclosure height. A reasonably large environment may be perceived as oppressive, enclosed, and with low openness depending on boundaries type and height.

The present study's hypothesis is that: (H1) the positive effect of seating ratio is limited to a maximum ratio, after which impressions deteriorate, and (H2) that the site's area conditions the effects with different effects to small, medium, and large environments.

Methods

The most effective way to evaluate the effects of different design elements on public space users' perception and impressions would be to create several design variations on real public space and measure users' behavioral changes, such as increased activities, stay time, or money spent. Although ideal, this approach would require a prohibitive investment to measure public space usage and create the necessary design variations, and it would still be questionable whether the observed effects were restricted to that site or applicable elsewhere.

Differences in users perception produced by public space design variation have been typically measured using drawings (STAMPS, 1993, 2003), manipulated still photographs (DOWNES; LANGE, 2015; KAPLAN, 1985; STAMPS, 1993, 1990), architectural models (MATSUMOTO; KANAZAWA; KITO, 2012; MOCHINAGA; ISHIDA, 2014), computer-generated images (AVALONE NETO; MUNAKATA, 2015), computer-generated environments (JANSEN-OSMANN; BERENDT, 2002) and walkthrough routines/videos (BISHOP; YE; KARADAGLIS, 2001). Technology today allows for the creation of game-like virtual environments that allow for free movement inside the modeled environment (PATTERSON *et al.*, 2017), which provides an inexpensive way to create several design variations and still allow for the environment to be perceived and evaluated as a whole and not from a specific viewpoint.

Immersive Virtual Environments (IVE) perceptually surround the individual in an interaction that provides a continuous stream of stimuli (WITMER; SINGER, 1998). Studies have found that real and virtual environments highly correlate for open public space settings such as plazas (OHNO *et al.*, 2006). Experiments using desktops and virtual environments have also been shown to yield similar results even for activities such as distance judgment (JANSEN-OSMANN; BERENDT, 2002), personal space (WILCOX *et al.*, 2003), seat selection (OHNO *et al.*, 2006), and seat choice (AVALONE NETO; MUNAKATA, 2015).

The specific use of IVE for measuring perceptions and impressions of public space users has been tested by Avalone *et al.* (2016). They found no significant difference between virtual and real environment responses, as long as the CG model's minimum detailing levels were maintained, such as material textures and similar greenery in the virtual model.

Ultimately, any method has to balance between experimental control and mundane realism. Real settings have the most mundane realism, with no experimental control. While traditional environmental simulation methods such as drawings, still pictures, and desktop-based virtual environments may have a high trade-off, IVE allows for the most experimental control at a minimal cost of mundane realism (BLASCOVICH *et al.*, 2002).

Therefore, immersive virtual environments (IVE) were used to test the effects of different seating ratios and environment size combinations. For comparative purposes, this is the same methodology adopted by Avalone *et al.* (2017). Variables had three levels each, as shown in Table 1. *Seating ratio* is the aggregate area occupied by all seating furniture in the environment divided by the total floor area. The seating furniture adopted is a round table with four chairs (Figure 3). A distinction is purposefully made in this article between *seating ratio,* which is the area occupied by all the seating furniture and the independent variable being manipulated, and *seating amount* – used to indicate users' perception of seating quantity and a dependent variable in one of the perception measurement scales.

	Small ($600m^2$)	Medium ($2000m^2$)	Large ($3500m^2$)
Seating ratio at 1%	S01	S04	S07
Seating ratio at 3%	S02	S05	S08
Seating ratio at 10%	S03	S06	S09

Table 1: Stimuli matrix.
Source: authors, 2017.

The stimuli controlled for all variables except *seating ratio* and POPS area. They were created using SketchUp software and compiled into the software Unity for the final environments. All samples had 10% of floor area covered by bushes and 50% covered by trees. The site was always open on three sides, while the fourth side was occupied by a 120m tall (34 floors) building with a coffee shop on the ground level. Surrounding streets were 7m wide, and all sidewalks were 4m wide. The plaza's total area included the sidewalk area (Figs. 1, 2, and 3). Stimuli were presented to participants using an Oculus Rift DK2 head-mounted display (HMD), and participants were able to move around the environment using a Logicool F710 gamepad.

The questionnaire consisted of five scales related to perceived suitability for different activities, nine scales regarding environmental impressions, seven scales regarding the environment's perception, and two scales regarding the overall perceived value (Table 2). Questions 1 to 21 were a 7 point semantic differential scale, while questions 22 and 23 were rating scales. They were presented in paper format after the participant examined each environment.
Participants were still able to see the environment through the monitor and move

through it while answering the questionnaire. They could put on the IVE goggles again, even in the middle of the questionnaire, if they wished.

There were 20 participants in the study (13 Male, 7 Female), all Japanese university students from different fields. Participants averaged 21.25 years of age (SD=1.52), and each of them evaluated all nine samples in a random order, resulting in 180 observations.

A power analysis was conducted to determine the sample size. Based on the data presented in Avalone *et al*. (2017), the following values were adopted: significance level of 5%, the standard deviation of 1, detection of differences higher than 0,7 points with a confidence of 80% yield a sample size of 19 participants. With 20 participants, the experiment may detect differences higher than 0,7 with a significance level of 5% with a power of 84%.

The analysis was made through a two-factor analysis of variance (ANOVA) with interactions. The predictor variables for each evaluation scale were *Seating Ratio* and the environment *Scale*. Tukey's HSD multiple comparison tests were also undertaken to test if the variables' means were significantly different and could thus be treated as distinct levels of that variable.

		Measurement	Scale
1	Activities	Suitability for stay	Unsuitable – suitable
2		Suitability for eat/drink	Unsuitable – suitable
3		Suitability for rest	Unsuitable – suitable
4		Suitability for Wait	Unsuitable – suitable
5		Suitability for read	Unsuitable – suitable
6	Impressions	Appeal	Not appealing – appealing
7		Interest	Not interesting – interesting
8		Enclosure	Do not feel enclosed – feel enclosed
9		Atmosphere	Gloomy – cheerful
10		Relaxation	Not relaxing – relaxing
11		Openness	Not spacious – spacious
12		Oppression	Do not feel oppressed – feel oppressed
13		Liveliness	Not lively – lively
14		Diversity	Uniform – diverse
15	Perceptions	Size	Small – large
16		Greenery amount	To little greenery – a lot of greenery
17		Greenery placement	Badly placed – well placed
18		Seating amount	To little seats – a lot of seats
19		Seating placement	Badly placed – well placed
20		Seating design	Badly designed – well designed
21		View	Bad view – good view
22		Willingness to Pay	From 0 to 1000 yen or more

Table 2: Adopted measurement scales. Source: authors, 2017.

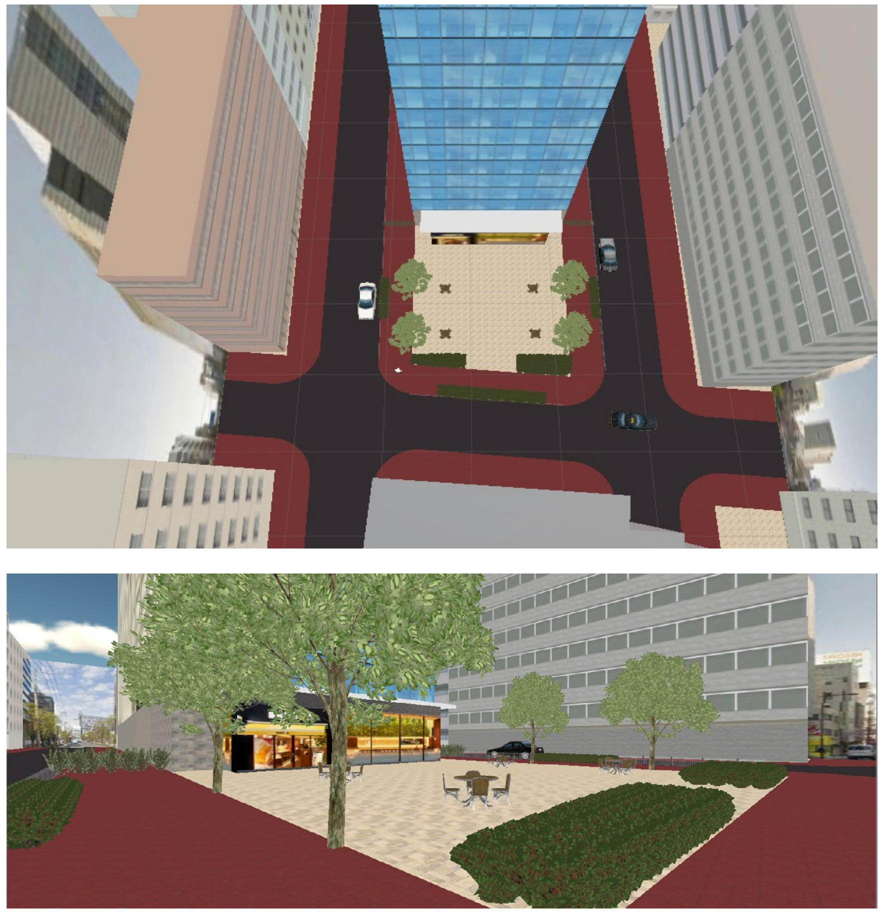


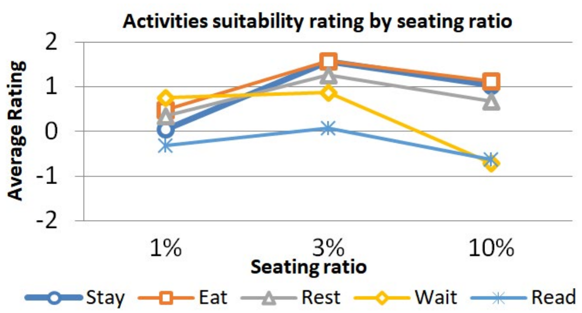
Figure 1: S1.Source: authors, 2017.

Figure 2: S5. Source: authors, 2017.

Figure 3: S9. Source: authors, 2017.

Results

Activities



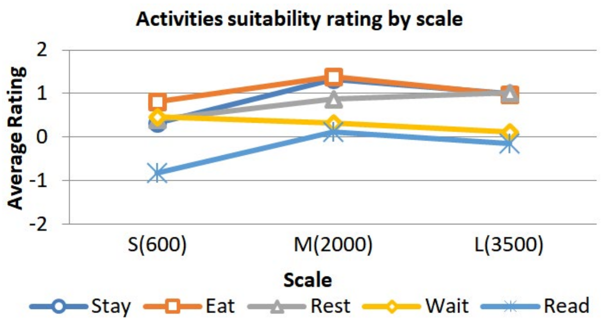


Figure 4: Activities average ratings by seating ratio.Source: authors, 2017. Figure 5: Activities average ratings by scale.Source: authors, 2017.

Increasing *Seating Ratio* from 1% to 3% increased perceived suitability for *Stay*, *Eat/drink,* and *Rest* activities, while raising it to 10% reduced perceived suitability (Figure4 and Table 3).
Seating Ratio did not affect *Read* activity. For *Wait* activity raising *Seating Ratio* from 1% to 3% produced no significant effect, but increasing it up to 10% negatively affected, reducing perceived suitability.

Environment *Scale* also showed an effect. For *Stay* activity, medium or large environments were the same, with no statistical difference, but small environments were perceived as worse than both. No interaction was observed (Figure5).

Small environments were less suitable than medium environments to *Eat/drink* and *Read* activity, and large environments were not statistically different from neither small nor medium environments. No interaction was observed for either *Stay*, *Eat/drink*, *Read,* or *Rest* activities (Figure 5 and Table 3).

For *Rest* or *Wait* activities, no effect of *Scale* was observed. In *Wait* activity, an interaction between small environments and seating ratio at 10% could be observed, and the environment Scale mitigated the negative effect of a high Seating Ratio.

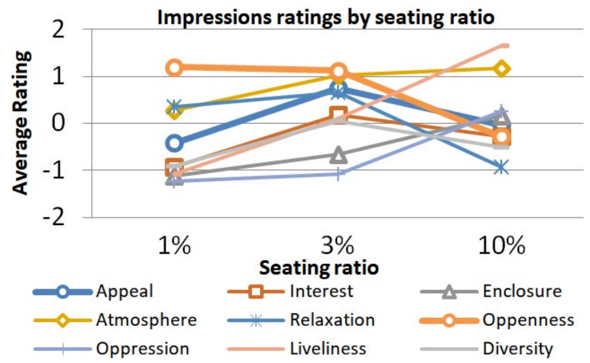
Differences between *Wait* and other activities may originate from visual search, a behavior required for wait activity but not required by other activities. The more things occupy the field of vision, the more strain a visual search requires, but an environment with only 600m^2 may be small enough that more elements in the visual field will not cause strain since the environment may be fully grasped with ease.

	Stay	Eat/drink	Rest	Read	Wait
Seating Ratio	21.00**	12.30**	5.89**		20.42**
Scale	8.93*	3.51*		5.15*	
SR x Scale					2.50*
R^2	0.27	0.19	0.12	0.12	0.23

Note: values expressed are F (2,171); ** = p<.0001; * = p<0.005.

Table 3: Effect of Seating Ratio on Perceived Suitability for Different Activities. Source: authors, 2017.

Impressions:



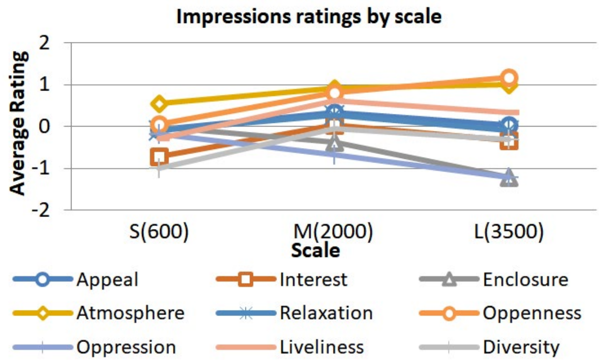


Figure 6: Impressions average ratings by seating ratio. Source: authors, 2017. Figure 7 : Impressions average ratings by scale. Source: authors, 2017.

Increasing *Seating Ratio* up to 3% improved participants' impression of the environment's *Appeal*, *Interest*, *Atmosphere*, and *Diversity*, but increasing past 3% worsened it (Figure6).

For *Relaxation*, *Openness, Oppression,* and *Enclosure,* there was no effect when *Seating Ratio* was increased from 1% to 3%, but an effect could be seen between 1% and 10%. The impressions were worst with seating at 10% of floor area ratio, and environments were perceived as less *Relaxing*, less *Open,* more *Oppressive,* and more *Enclosed* (Figure6).

Liveliness increased as *Seating Ratio* increased, and no upper limit was found for this effect. It probably relates to the environment affordance – the more seats, the more the environment allows it to be bustling with activities. It is worth noticing that the simulated environments had no people in them but empty chairs. One may assume that many empty seats would signalize the absence of people (and the opposite of liveliness), but since all environments were equally empty and since humans make comparative rather than objective judgment, it is reasonable to assume that the affordance for liveliness was assessed. This assessment may change with different amounts of people occupying the environment (e.g., one person occupying only one seat in a 10% seating ratio environment), but that still has to be tested in further studies.

Table 4: SR and Scale Effects on Impressions.Source: authors, 2017

	Appeal	Interest	Enclosure	Atmosphere	Relaxation	Openness	Oppression	Liveliness	Diversity
Seating Ratio	12.23**	12.71**	9.09*	7.57*	18.92**	19.02**	18.77**	69.40**	7.25*
Scale		5.67*	7.90*			8.93*	7.35*	8.16*	7.73*
SR x Scale									
R^2	0.17	0.20	0.17	0.11	0.21	0.25	0.24	0.49	0.17

Note: values expressed are F (2, 171); ** = p<.0001; * = p<0.005.

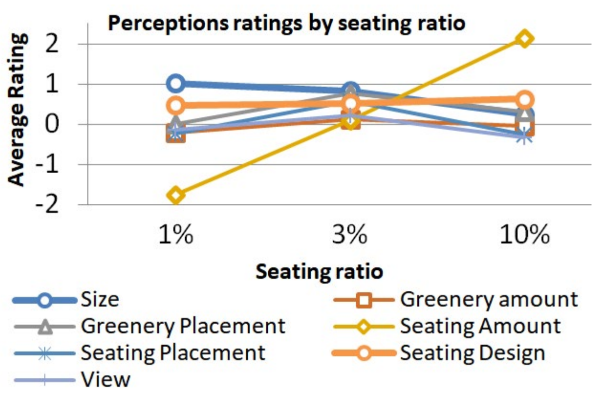
Interest, *Liveliness,* and *Diversity* were also affected by *scale,* and small environments were worse than medium ones. No difference between medium and large or small and large environments was observed, nor were any interactions (Figure7).

Feelings of *Enclosure* and *Oppression* were mitigated by the *Scale* of large environments (3500m²), although small and medium environments were statistically the same. No interaction was observed (Table 4 and Figure7).

The opposite happened to *Openness*: medium and large environments were perceived as more open than small scale environments, although no statistical difference could be observed between medium and large environments, and no interaction was observed (Figure7).

No effect of *Scale* or interaction could be observed for *Appeal*, *Atmosphere,* or *Relaxation*.

Perception:



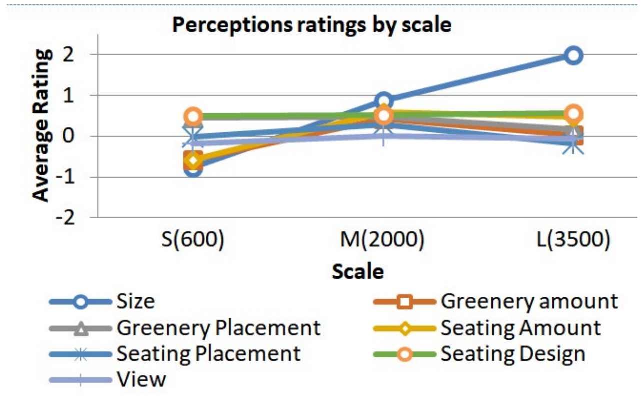


Figure 8: Perceptions average ratings by seating ratio. Source: authors, 2017. Figure 9: Perceptions average ratings by scale. Source: authors, 2017.

There was an effect of *Seating Ratio* in the perception of environment *Size* and *Seat placement*. Increasing *Seating Ratio* up to 10% will make the environment feel smaller and with worse placed seats. This effect probably occurred due to cluttering. No statistical difference was found between *Seating Ratio* levels of 1% and 3%.

The perception of *Seating Amount* matched the actual *Seating Ratio* at all variable levels, showing that no perception bias arose from the method chosen (Figure8).

Although the data shows an effect of *Seating Ratio* in *Greenery Placement,* since the environment changes its size, greenery was placed differently (e.g., different distances from the curb), making it impossible to say if the observed effect is the effect of bias or actual greenery placement.

The *Seating Ratio* did not affect the perception of *Greenery Amount*, *Seat Design,* or *View* (Figure8 and Table 5).

Size perception did match the actual environment scale at all levels, showing that no scale perception bias arose from the selected method. No interaction between *Seating Ratio* and environment *Size* was observed (Figure9).

Table 5: SR and Scale Effects on Perceptions. Source: authors, 2017.

	Size	Greenery Amount	Greenery Placement	Seat Amount	Seat Placement	Seat Design	View
Seating Ratio	5.49*		4.96**	232.70**	5.31*		
Scale	66.29**	8.66*	0.95*	24.93**			
SR x Scale							
R^2	0.46	0.11	0.10	0.75	0.10		

Note: values expressed are F (2, 171); ** = p<.0001; * = p<0.005

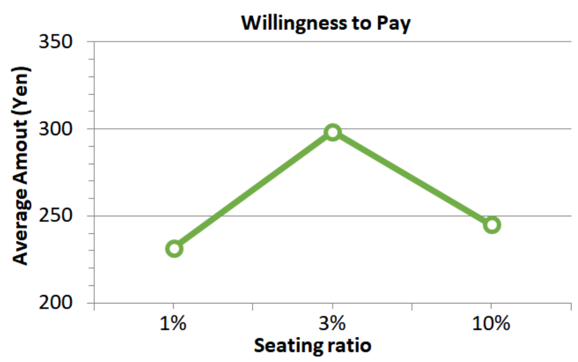
The effect of *Scale* could be observed in the perception of *Greenery Amount* and *Seating Amount*. Small environments were perceived as having less greenery and fewer seats than medium or large-scale environments with the same ratio (i.e., greenery at 10% of floor area). No interaction was observed (Figure9 and Table 5).

No effect of *Scale* or interactions could be observed in the perception of *Seat Placement*, *Seat Design,* or *View*.

Willingness to pay and willingness to stay:

No valid model that included both seating ratio and environment scale as predictors of willingness to pay and willingness to stay could be made. When considering only seating ratio as a predictor, a small effect ($R^2 = 0.06$; $F(2, 177) = 5.19$; p = 0.0065) in *Willingness to Pay* could be observed. It increased when the *Seating Ratio* rose to 3% of FAR but diminished as it reached 10% (Figure10). Environment *Scale* did not affect *Willingness to Pay,* and no interaction was observed.

Willingness to Stay was also affected (R^2=0.09; F(2, 171) = 6.07; p=0.0028) by *Seating Ratio* with increasing duration up to 3% and diminishing durations at 10% (Figure11). No effect of *Scale* or interactions was observed.



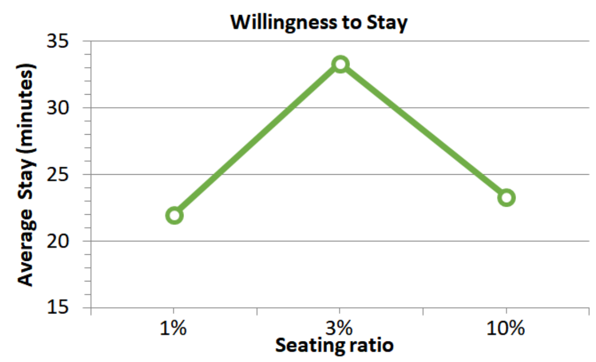


Figure 10 : Average amount people were willing to pay by seating ratio. Source: authors, 2017. Figure 11: Average time people were willing to stay by seating ratio. Source: authors, 2017.

Effects of sex

The averaged data by stimuli and sex was used to analyze the effects of sex, resulting in 18 data points. Each data point was the average answer of each sex for a given stimulus. It corresponded to the averaged response of 7 participants when females and 13 participants for male data points. An analysis of variance using male and female averaged responses for the nine stimuli was conducted.

From the 23 different evaluation scales (Table 2) only the perception of *Seat Design* was affected by sex ($R^2 = 0.86$; F (1, 17) = 96.79; $p < .0001$), with women perceiving seats as better designed than man. All other evaluation scales had no significant sex effect.

Effects of architectural background:

The architectural background effects were tested using an averaged answer by background and stimuli, resulting in 18 data points – one for each stimulus and background. An analysis of variance using the background as predictors for each of the 23 evaluation scales was conducted.

Four evaluation scales were affected by architectural background: *Appeal* ($R^2 = 0.28$; F (1, 17) = 6.12; p = 0.0250), *Diversity* ($R^2 = 0.25$; F (1, 17) = 5.22; p = 0.0363), *Greenery Amount* ($R^2 = 0.29$; F (1, 17) = 6.41; p = 0.0222) and *View* ($R^2 = 0.34$; F (1, 17) = 8.12; p = 0.0116). All other scales had no significant effect of architectural background.

Participants with architectural background found environments to be less appealing, less diverse, having less greenery, and having a worse view, in agreement with Llinares & Inarra (2014) and Akalin, Yildirm, Wilson & Kilicoglu (2009) that people with an architectural background are more critical of the environment than laypeople.

Discussion:

Generally, *Seating Ratio*'s effects improve with increases up to 3%, and the effects rapidly diminish or worsen as it approaches 10%. These findings agree with Whyte (1980), which established a seating ratio of about 4.37% for NYC. The results also qualify Gehl's (2011) assertion that seats are an essential element for a stay to occur and Mehta's (2007) findings that seats are crucial for street activity. Not all seating is equally desirable, with more than 3 to 5% ratios having no effect or hindering users' perception of the built environment.

This result may be used in conjunction with Jiang's (2015) dose-response curve for the relationship of tree cover density and landscape preference to inform designers about the effects different amounts of elements used in the space composition will have on users.

The present study results could be combined with Avalone Neto et al. (2017), which showed no discrepancies, allowing for a more refined description of the effects different seating rations have on public space users.

Regarding the effects in perceived suitability for different the optimal ratio to stay, eat/drink, and rest activities are between 3 and 5% of floor area (Figure 12). *Seating Ratio* received similar ratings at 3% or 5% for all activities and impression scales (Figure 12 and Figure13).

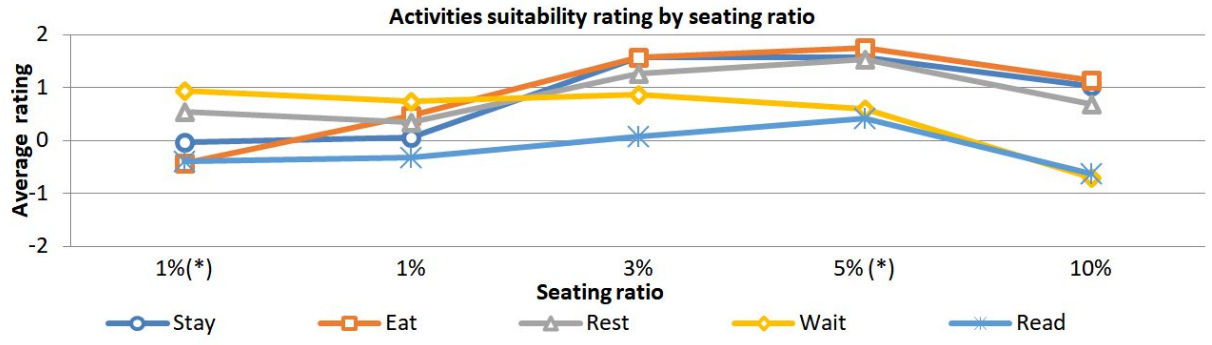


Figure 12: Compiled activities average ratings by seating ratio. "(*)" denotes results obtained from Avalone Neto et al. (2017). Source: authors, 2017.

Impressions followed one of three distinctive patterns: a) score improved linearly, as *Seating Ratio* increased: this happened to *liveliness*, *oppression*, and *openness,* in agreement with Imamoglu (2000), Stamps & Krishnan (2006), and Stamps (2007); b) score improved up to 3 and 5% and worsened past 5%: *appeal*, *interest*, *relaxation,* and *diversity*; and c) score improved linearly up to 5% and remained the same past that point – *enclosure* and *atmosphere* (Figure13).

The effects found agree with Avalone *et al*. (2017) except for *openness*, *oppression,* and *relaxation,* which showed no effect in their study. This difference is not unexpected since they worked with four sites of different sizes and configurations with no control for scale effect, and the present study tested for the effect of scale and its interaction with seating ratio.

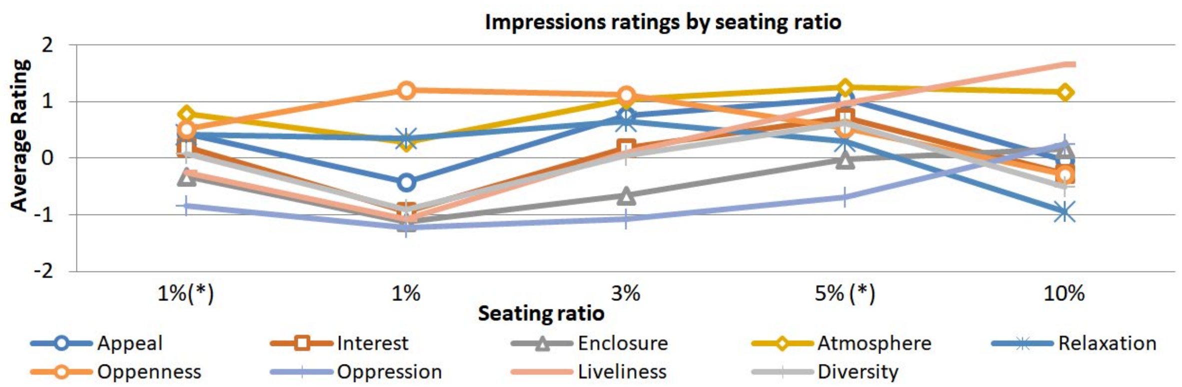


Figure 13: Compiled impressions average ratings by seating ratio."(*)" denotes results obtained from Avalone Neto et al. (2017). Source: authors, 2017.

Seating Ratio had a similar effect as Avalone Neto *et al*. (2017) in the *perception of size*, *greenery amount*, *greenery placement*, *seating amount,* and *seating placement* (Figure 14). Differences were found, however, regarding the perception of *seating design* and *view*. While Avalone Neto *et al*. (2017) found a positive effect of *Seating Ratio* on those scales, no effect was found in the present study. This discrepancy may also be attributed to the fact that they investigated four different sites with different seat designs and surrounding buildings – and this study controlled for such variables.

This study also found an effect of *scale*, as expected by Avalone Neto *et al*. (2017). Small environments (600m²) were, indeed, perceived as less suitable for *stay*, *eat/drink* and *read* activities (Figure5). In agreement with Stamps & Krishnan (2006) and Stamps (2007), small environments were perceived as more enclosed, less open, and more oppressive, as well as less *interesting*, less *lively,* and less *diverse* than bigger environments built with the same element composition (Figure 7).

Small environments were perceived as having *less greenery* and *less seating* than larger environments, which substantiates that the perception of smaller environments (600m²) is different from medium (2000m²) or large (3500m²) scale environments

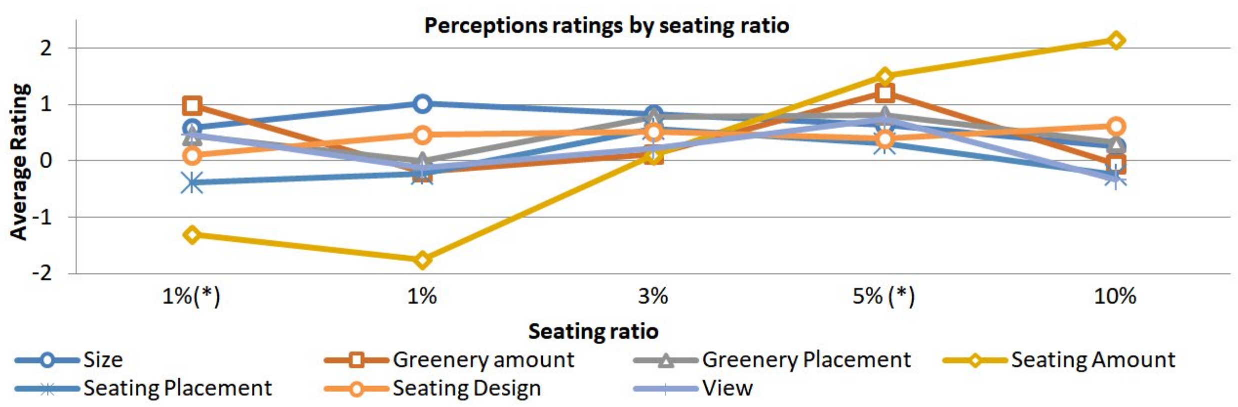


Figure 14: Compiled perceptions average ratings by seating ratio. "(*)" denotes results obtained from Avalone Neto et al. (2017). Source: authors, 2017.

(Figure9). In small environments, the user can grasp the whole environment at a glance. In this situation, it appears that users register the environment "by numbers" (i.e., "*there are three seats here*") while in larger environments, this is not possible, and a perception "by area" (i.e., "*there is a lot/not enough seats here*") seems to be used. This hypothesis would agree with Kaplan's (1980) understanding that a large space with smaller regions is preferred over one large space, although further research is needed to test it.

As with previous studies, increasing the *Seating Ratio* to 3% of FAR also increased *Willingness to Pay and Stay*. This effect shows a perceived improvement in the overall environmental quality and not only in specific individual metrics: users perceived the environment as, overall, better, and they were willing to stay longer and pay more based solely on the number of seats in the POPS.

It is worth stating that this study was made with small sample size, meaning that it was not designed to detect differences smaller than 0,7 points in participants' responses, and even at variations greater than 0,7 points, it still may not have detected since the designed power was about 84%. Further studies with a broader sample size may detect more subtle effects ignored by this study. Furthermore, the sample was extremely limited regarding age, socio-economic, and cultural background since the participants were all Japanese university students in their 20s. A broader study with larger sample size and a more representative population is necessary for any generalizations of the results.

Conclusions:

This study tested the effects of seating ratio on public space users to determine the threshold between the increased seating amount's positive and negative effects.

It found that threshold to be around 5% of floor area ratio with effects either not improving or worsening at higher ratios.

Instead of the standard 'preference' measure, it tried to measure the specific effects on perceived suitability for different activities, users' perceptions, and impressions of the built environment to find that not all effects are the same.
While increasing *Seating Ratio* up to 5% of FAR increases environment suitability for *Stay*, *Eat/drink* and *Rest* activities, for *Wait* activity, the opposite happens, and no effect could be consistently observed in *Read* activity.

Impressions of environments' *Appeal*, *Interest,* and *Diversity*, will also improve when *Seating Ratio* increases up to 5% but will worsen past it. Other impressions are linearly affected by seating ratio and will consistently be affected by it, such as *Enclosure*, *Openness*, *Oppression,* and *Liveliness. Atmosphere* improves up to 5% and stagnates, while *Relaxation* is constant up to 5% when it starts to worsen.

Seating Ratio also affects how the environment is perceived. Increasing its ratio past 5% will cause the environment to be perceived as smaller and *Seat Placement* as worse.

Increasing *Seating Ratio* up to 5% will increase *Willingness to Pay and Willingness to Stay,* while further increases will worsen it. Considering only *Willingness to Pay*, *Seating Ratio* at 10% is as bad as only 1% of the floor area ratio, which offers an economic incentive to developers to increase seating quantity up to 5% of FAR as it may translate into revenue for surrounding services.

Whyte's (1980) recommendation to the NYC zoning board continues to be valid, and, overall, *Seating Ratio* seems to be ideally between 3 and 5% for most activities, impressions, and perceptions. The exception to this is *Wait* activity, which appears to require the opposite of other activities.

Small environments (600m²) were perceived as less suitable than medium environments (2000m²) for all (stay, eat/drink, rest, and read) except wait activity. This difference in perception probably occurs because small environments reduce distances among people, possibly making them feel uncomfortable. There is a necessary distance between people passing by and people staying in the environment, and the smaller scale studied (600m²) does not seem to provide it. Wait activity requirements are different from other activities since searching for others or making oneself visible requires less strain in smaller environments than larger ones, making smaller environments more desirable for this activity.

Small environments were worse than other environments in practically all impression and physical scales, and they do seem to be perceived somewhat differently than other scales and, as so, should adopt different design strategies.

In some cases, large scale (3500m²) environments also were less favorable than the medium scale (2000m²) ones. It seems that an environment with an area up to 2000m² may still be designed and perceived as one space instead of several conjoint spaces. Larger environments could be divided into smaller sections with different characteristics that may be perceived as different environments. When an environment is as large as 3500m² and does not vary in design, it becomes monotonous, and it directly affects users' perception, impressions, and the environment's perceived suitability for different activities.

This study did not test for several other factors that may directly affect the perception of seating ratio in the environment. The most apparent is seat placement: the same amount/ratio of seating placed in different configurations may elicit different impressions in public space users and should be further tested. It also did not test for seating design or material, which may also have a direct effect.

There is still much to be explored about public space design elements such as ground cover, bushes, tree cover, urban furniture, food stands, small amenities, environment enclosure, maintenance level, crowding, event programming and local identity, for instance, and the relation with seating amount, type, material, placement, and so many other variables. This study is by no means a definitive result about the quantification of seating but merely tries to shed some light on how urban designers manipulate design elements to compose the environments that will nest and shape human activity in our cities.

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