Physical Element Effects in Public Space Attendance

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Abstract

This paper seeks to determine which physical elements of privately owned public spaces affect users' impressions, which characteristics of these elements are noticed, and what impressions they cause. The study is based on a caption evaluation and semantic differential survey of 12 public spaces in the center of Tokyo. Ten participants were surveyed for each space, and 1494 of the obtained entries were analyzed. The semantic differential survey was then cross-referenced with density measures to evaluate the effect of physical elements' densities on participants' impressions.

It was found that the physical elements that caught users' attention were greenery, street furniture, the building, the sidewalk and the space itself. From all of the elements, tree coverage density was the best predictor of desire to stay and rest activities in the space. A logistic regression analysis of each activity by tree density is also provided.

Keywords: behavior; public space; caption evaluation; semantic differential; impression

1. Introduction

In 1961, New York City started to offer a floor-area ratio (FAR) bonus to ensure the provision of public spaces on the ground level (Whyte, 1988; Smithsimon, 2008). This practice has since been widely used by different countries and is generally referred to as "increasing FAR". In Japan, similar policies have been adopted since 1971 through the Comprehensive Design System (Sogo Sekkei Seido) and have been used as a deregulation policy since the 1980s to promote urban redevelopment through the Building Standards Law (Kenchiku Kijun Hou) (Akamine *et al.*, 2003; MLIT, 2003).

In 2015, there were approximately 720 privately owned public spaces (POPS) in the Tokyo area alone. Lately, the design of public spaces generated by these policies has considered not only the lot area but also the integration of the public space with its surroundings, thereby connecting the lot to existing spaces and infrastructures. This design has played an important role in the production of public spaces.

Although POPS are widely recognized for enhancing the quality of public spaces and are a valuable urban development tool, there is little research regarding the quantification and placement of the physical elements that compose those plazas and the effects on users' impressions and behaviors. This leaves the design of POPS to each designer's individual ability and personal judgment.

This research seeks to improve the knowledge about the effects of physical elements on users' impressions and behavior and to fill the gap in knowledge so that urban planners can create evidence-based designs and reduce the difference between expected and actual effects on users' impressions by the built environment.

1.1 Physical Elements and Users' Impressions

Some studies sought to establish a relationship between POPS physical elements and the impressions they caused. Kakutani (2005) used the semantic differential method (SDM) to evaluate POPS produced through the comprehensive design system in Hiroshima. He analyzed overall area and typology relations of public spaces on users' impressions with a focus on policy making rather than public space design.

Fujita & Ito (2006) characterized POPS in the Minato ward of Tokyo by its connections with walking paths and evaluated them based on pedestrian traffic

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and traffic direction. Their results are somewhat useful for building placement and policy decisions.

According to Tanaka & Kikata (2008), physical elements such as benches and stairs/steps are directly related to a good impression of public spaces for stay, rest and passing through activities. However, their research was limited to three public spaces in Kagoshima with the caption evaluation method.

Tsuchida & Tsumita (2005) studied how the physical characteristics of the public space affect wait and rest activities. They selected 16 areas in different POPS and asked participants to mark on a map the areas where they would want to stay or rest and give their reasoning. The study indicates a positive effect of *greenery* and *seats* on rest activities, while *greenery* has a negative and *visibility* a positive effect on wait activities. Unfortunately the study asked participants to adopt one of two pre-determined behaviors: rest or wait. If participants were allowed to evaluate the environment for any behavior, a better relationship between behavior, physical aspects and impressions could have been established.

2. Study Area and Sample Size

For the purpose of this study, 12 POPS in the center of Tokyo with lot areas larger than 3000 m^2 constructed after 1990 were chosen (Table 1.).

Table 1. Sites Chosen for the Survey

Site	Ward	Lot area [m^2]	Open space ratio	Built in
Building 01	Chiyoda	6383	52.2%	2011
Building 02	Chiyoda	20875	75.0%	2003
Building 03	Chiyoda	6079	45.8%	2003
Building 04	Minato	3647	47.5%	2004
Building 05	Chiyoda	6368	54.0%	1999
Building 06	Minato	3039	50.6%	2003
Building 07	Minato	3217	57.1%	2009
Building 08	Minato	15206	65.6%	2006
Building 09	Minato	5479	56.3%	2006
Building 10	Chiyoda	3101	53.7%	2006
Building 11	Bunkyo	3417	52.0%	1998
Building 12	Shinjuku	3734	61.9%	2009

Data were gathered over 4 days in October and November 2010 from 12:30 to 17:30, on sunny or partially cloudy days (16ºC – 19ºC) that offered suitable weather conditions for outside activities.

Questionnaires were collected from a total of 30 participants (23 males and 7 females), aged between 21 and 29 years (M=23; SD=1.54), university students who were randomly assigned to visit four of the 12 sites. Each site had an average of 10 participants, leading to a total of 120 site observations.

All participants in this study were architecture students for practical reasons because they develop a specialized language (Wilson, 1996) that facilitates built environment description. A laypersons description of the environment would be in too broad terms or too ambiguous for the purpose of this study.

Although there are several studies (Hershberger, 1969; Devlin & Nasar, 1989; Nasar, 1989; Devlin, 1990; Stamps, 1991; Hubbard, 1994; Brown & Gifford, 2001) that found a perceptual difference between architects and non-architects, those differences are related to the overall evaluation of building facades made from pictures or slides and not real environments or public spaces.

Other researchers also found no difference between architects and laypersons (Nasar & Purcel, 1990; Imamoglu, 2000), showing that correlation is dependent on the evaluation scales and the object of evaluation. On the evaluation of outdoor spaces using semantic differential scales no difference was found between architects and laypersons measuring variation, friendliness, functionality and desirability scales (Yazdanfar *et al.*, 2015).

3. Methods

3.1 Caption Evaluation Method (CEM) Survey

A CEM survey was conducted to identify which physical elements to select from those commonly found in POPS, how they are evaluated and which impressions are caused within users. Based on users' responses to different environments, a structural relation between physical elements, element characteristics and impressions was constructed.

This method was chosen because it allows real environment evaluations while prompting users to note which elements caught their attention and what impressions they caused.

In a CEM survey, participants move freely (e.g. walk around, sit) in the environment with a camera and photograph elements that catch their attention. Participants will then take note about why that particular scene caught his or her attention with a subtitle for each picture. Later, each picture is attached to an evaluation card in which the participants describe (characterize) the picture's scenery or elements and the reason (impression) it caught their attention (Koga, T., Taka, A., Munakata, J., Kojima, T. *et al.*, 1999; AIJ, 2011).

Participant's evaluations were made by describing the elements that caught their attention, their characteristics and the impressions they caused under the following structure: ○○is ○○ because ○○; where "○○" is the element, characteristic and impression, respectively. Participants could take and evaluate as many pictures as they wished and write as many entries per picture as they deemed necessary (M=12.14; SD=5.93). From the 120 site visits, a total of 1494 entries were made. These entries were classified and divided into groups using the KJ method, which agglutinates answers by similarity. All answers where categorized into medium and macro groups of elements, characteristics and impressions (Figs.1., 2. and 3.).

Overall, elements were classified into 11 macro categories composed of 64 smaller ones (Fig.1.); characteristics were classified into 10 macro categories composed of 40 smaller ones (Fig.2.); and impressions were classified into 9 macro categories composed of 45 smaller ones (Fig.3.).

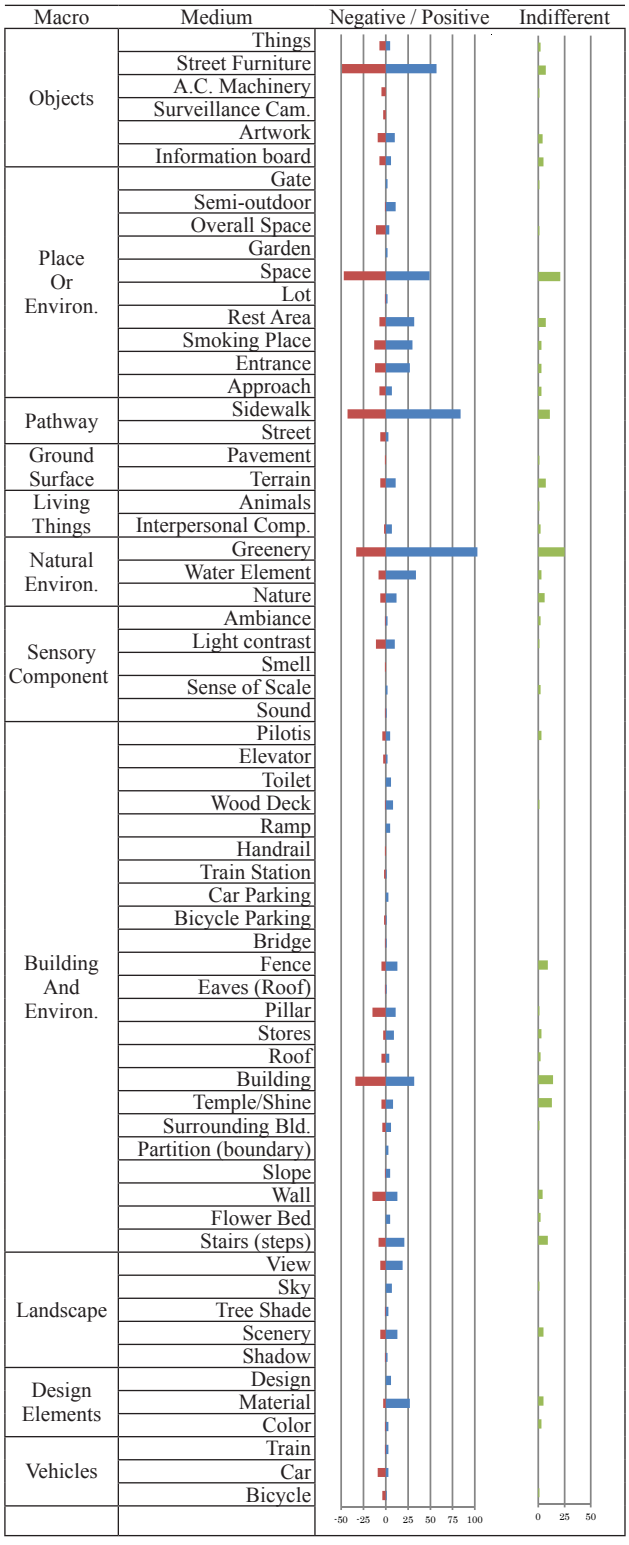

Fig.1. Elements Extracted from the CEM Survey

Between the *elements* pointed out by the participants, greenery was the most relevant, with 256 entries (E) (77% positive (P), 13% negative (N) and 10% indifferent (I)), followed by sidewalks (138 E, 61% P, 31% N and 8% I), space (117 E, 42% P, 40% N, 18 I), street furniture (113 E, 51% P, 43% N, 6% I) and building (80 E, 40% P, 42% N, 18% I). All other characteristics had less than 46 entries overall.

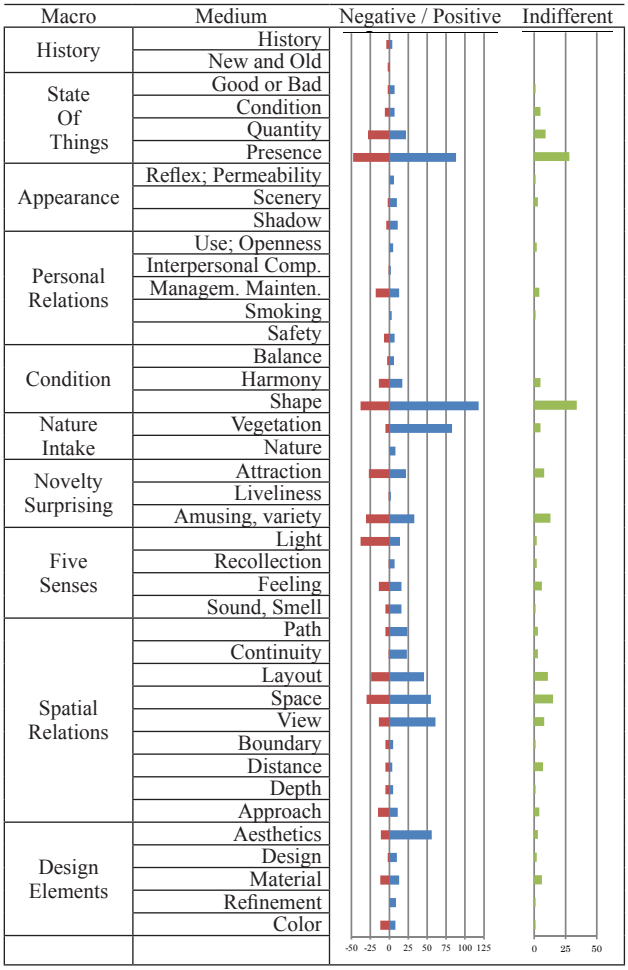

Fig.2. Characteristics Extracted from the CEM Survey

From the element *characteristics* noted by the participants, shape was the most prominent (190 E, 62% P, 17% N, 21% I), followed by presence/absence (164 E, 54% P, 29% N, 17% I), space composition (100 E, 55% P, 30% N, 15% I), vegetation (93 E, 90% P, 5% N, 5% I), view (83 E, 73% P, 17% N, 10% I), placement (81 E, 57% P, 30% N, 13% I), amusement/variety (77 E, 43% P, 40% N, 17% I) and aesthetics (70 E, 80% P, 16% N, 4% I). Other characteristics varied from a range of 3 to 59 entries (0.2% to 4%) as shown in Fig.2.

Comfort was the most cited *impression* (191 E, 68% P, 29% N, 3% I), followed by like/dislike (162 E, 78% P, 21% N, 1% I), restfulness (122 E, 55% P, 37% N, 8% I), entertainment (88 E, 60% P, 20% N, 20% I), space aspiration (87 E, 38% P, 21% N, 41% I), goodness (72 E, 96% P, 1% N, 3% I), usage (68 E, 49% P, 35% N, 16%

I), people walking (56 E, 54% P, 39% N, 7% I) and pleasantness (52 E, 67% P, 33% N). Other impressions varied from a range of 2 to 43 entries (0.13% to 3%) as shown in Fig.3.

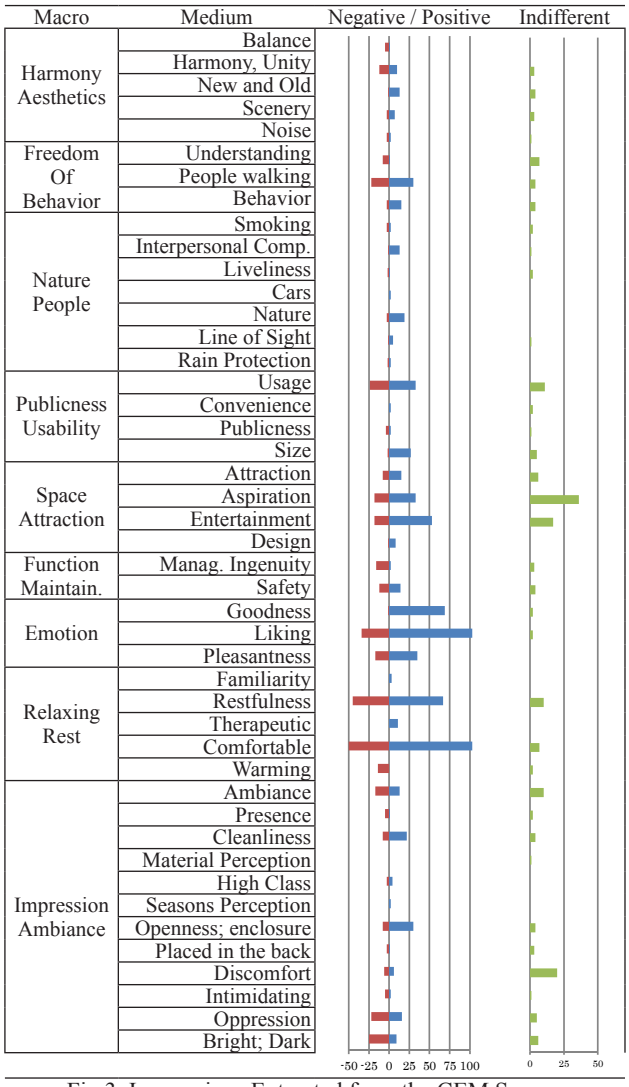

Fig.3. Impressions Extracted from the CEM Survey

3.1.1 Results

The overwhelming majority of answers identifying elements that attract attention pointed to tangible physical elements that compose the built environment (i.e., greenery, sidewalk, street furniture and building) or to the intangible that is the sum of those elements (i.e., space). Those five categories alone account for 704 (47%) of the 1494 entries gathered in the survey.

Of the characteristics, the shape of the environment or things (12.7%) and the presence or absence of elements were the most cited (11%), and three (placement, space composition and view) of the nine categories of spatial relation combined accounted for 17.7% of entries (264 E), while vegetation accounted for 6.2% of entries.

The data regarding users' impressions showed that comfort (12.8%) and personal emotions (i.e., like/dislike, good/bad, pleasant/unpleasant) were commonly felt and composed 18% of entries. Interpersonal impressions may also be observed in responses such as people walking, usage and entertainment (14% of entries combined).

3.1.2 Discussion

The results show that the basic elements that form a POPS (i.e., greenery, sidewalk, street furniture and building) are the same ones that will attract or repel users. Although this may seem to be an obvious conclusion, the magnitude to which these elements are perceived in relation to other elements (Fig.1.) is surprising, and the perception of intangible components is almost insignificant (e.g., all five categories in the sensory component category combined accounted for only 34 entries or 2.28%). Based on these results, future research should seek further evidence for how and to what extent these basic elements affect users' perceptions.

This can also be observed in the characteristics pointed out with entries that directly relate to tangible design decisions such as the presence or absence of elements and vegetation, form, placement and space composition. Although this has been explored in previous research (Tanaka & Kikata, 2008; Tsuchida & Tsumita, 2005), directives regarding how to manipulate these variables in public space designs to garner specific impressions from users are limited.

Impressions are very closely related to personal opinion (e.g., is the environment good/bad, liked/disliked, pleasant/unpleasant, etc.). More subtle aspects of impressions, such as the ambience categories (Fig.3.), had few entries on average, which suggests a very simple perceptual structure: an important element is sought; the relationship between that element and the overall structure (presence, shape, placement, and aesthetics) is perceived; and the personal opinion of that characteristic is felt (like/dislike, good/bad; pleasant/not; comfortable/not).

The results are limited by the participants age group (M=23; SD 1.54) and specialty (architecture students). Furthermore, the present study could not control for individual differences or the possible effect of subjects and site combinations. The analysis considers entries for all 12 POPS and difference between sites will be investigated in future research.

3.2 Semantic Differential Evaluation and Density Analysis

To analyze how much of each element was used in each project and their effects on users' impressions, a semantic differential questionnaire combined with the element density measurements was used. The element density was defined as the amount of area occupied by an element divided by the publicly accessible area of the lot. The publicly accessible area was defined as the lot area minus the buildings' enclosed or otherwise not freely accessible areas. Areas were analyzed in two different layers: ground level (seats, bushes, hedges and water) and coverage (trees and cover). Therefore,

the areas of those two layers may overlap: a tree covering a seat was counted for its seat area in the "seat" category, while the tree canopy area was counted in the "tree" category (Table 2.).

Table 2. Site Area Ratio per Category

Site	Seats	Bushes	Hedges	Trees	Cover	Water
Building 01	0.015	0.266	0.005	0.282	0.046	0.004
Building 02	0.014	0.259	0.020	0.240	0.049	0.013
Building 03	0.021	0.124	0.061	0.208	0.00	0.00
Building 04	0.003	0.132	0.017	0.257	0.294	0.014
Building 05	0.034	0.302	0.09	0.26	0.028	0.038
Building 06	0.002	0.228	0.052	0.138	0.244	0.00
Building 07	0.013	0.116	0.017	0.295	0.134	0.00
Building 08	0.011	0.203	0.114	0.242	0.031	0.00
Building 09	0.007	0.292	0.000	0.271	0.262	0.00
Building 10	0.01	0.23	0.049	0.092	0.20	0.00
Building 11	0.022	0.223	0.013	0.301	0.158	0.00
Building 12	0.00	0.161	0.12	0.096	0.026	0.00

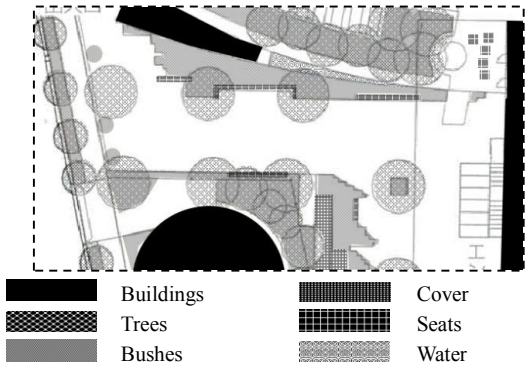

Fig.4. Density Measure of a Section of Bld. 01's POPS

Table 3. SD Questionnaire Measurement Scales

	Measurement	Scale
1	Comfort	Comfortable - Uncomfortable
2	Stay Duration	Long Stay – Short Stay
3	Size	Big – Small
4	Peacefulness	Peaceful – Loud
5	Sophistication	Sophisticated – Unsophisticated
6	Diversity	Diverse – Uniform
7	Liveliness	Lively – Decadent
8	Space Weight	Light – Heavy feeling
9	View	Good – Bad view
10	Organization	Orderly – Cluttered
11	Amount of Greenery	A lot – A little greenery
12	Vegetation placement	Good – Bad Greenery Placement
13	Abundance of Tree Shade	A lot – A little tree shade
14	Illumination	Bright – Dark
15	Calmness Feeling	Feel Calm – Do not feel calm
16	Safeness	Feel Safe – Do not feel safe
17	Openness	Feel – Do not feel openness
18	Oppression	Feel – Do not feel oppression
19	Enclosure	Feel – Do not feel enclosure
20	A Place to Rest	Easy – Hard place to rest
21	Interesting	Interesting – Not interesting space
22	Harmony with Surroundings	Harmonic – Disharmonic
23	Color Variety	Colorful – Colorless
24	Atmosphere	Light – Dark Atmosphere
25	Newness	Contemporary – Nostalgic
26	Enjoyability	Enjoyable – Lack of enjoyment

The density – amount of public space area occupied by each element – was measured based on the CEM survey photographs taken by the participants (for seats, bushes, hedges, trees, cover and water) and satellite images available on Google earth were also used as reference for tree coverage when images from October to November 2010 were available (Fig.4.).

To consider the impact that such elements have on users' impressions, a semantic differential survey was applied to participants with a total of 26 measurement scales. In this survey, two of the scales were related to behavioral intent: stay duration and a place to rest (Table 3.).

An analysis of the participants' average response per site and each site's physical characteristics was performed (Table 2.). Effects of gender were tested but were not statistically significant.

3.2.1 Results

Correlations between physical elements and impressions are listed in Table 4. Measurement scales that did not correlate well (bellow 0.5) with any physical aspect are omitted.

The best predictor for stay duration was the tree ratio (R^2adj=0.46; p<0.008) through the single regression analysis formula Y=-2.73+(10.19*Trees), where Y is the "stay duration" score.

Table 4. Correlations of Impression and Physical Elements

Code	Physical Element or Impression	Seats Ratio	Bushes Ratio	Hedges Ratio	Tree Ratio	Cover Ratio	Water Ratio
A	Seats ratio						
B	Bushes ratio	0.32					
C	Hedges ratio	0.01	-0.13				
D	Trees ratio	0.48	0.12	-0.53			
E	Cover ratio	-0.49	0.01	-0.53	-0.02		
F	Water Ratio	0.58	0.39	0.14	0.25	-0.19	
1	Comfort	0.05	-0.20	0.01	0.59	-0.31	0.07
2	Stay Duration	0.15	0.06	-0.08	0.72	-0.29	0.12
4	Peacefulness	0.29	-0.23	0.29	-0.19	-0.54	0.40
5	Sophistication	-0.65	-0.48	0.41	-0.35	0.06	-0.29
6	Diversity	-0.08	0.10	0.21	0.40	-0.18	0.26
9	View	-0.19	-0.09	0.56	0.01	-0.36	-0.35
10	Organization	-0.47	-0.56	0.21	-0.48	0.16	-0.34
11	Amount of Greenery	0.50	0.08	0.33	0.31	-0.83	0.22
12	Vegetation placement	0.15	-0.18	0.17	0.41	-0.62	0.09
13	Abundance of Tree Shade	0.68	0.05	-0.12	0.72	-0.67	0.22
15	Calmness Feeling	0.24	-0.15	-0.16	0.65	-0.27	0.28
19	Enclosure	0.40	0.24	-0.42	0.12	0.28	0.60
20	A Place to Rest	0.33	0.18	-0.59	0.93	0.05	0.28
21	Interesting	-0.16	-0.24	0.06	0.47	-0.08	0.12
22	Harmony with Surrounding	0.16	-0.05	0.10	-0.18	-0.14	-0.34
23	Color Variety	0.04	-0.03	0.50	0.26	-0.57	0.22
25	Newness	-0.63	-0.31	0.13	-0.44	0.11	-0.22

A place to rest could also be predicted by tree ratio with a better model (R^2adj=0.85; p<0.001) through the formula Y=-3.80+(16.73*Trees), where Y is the "place to rest" score. This prediction could also be made from the hedge ratio but with a less robust model (R^2adj=0.27; p<0.045).

Several impressions could be predicted from the tree ratio: tree shade (R^2adj=0.47; p<0.008), calmness (R^2adj=0.36; p<0.023) and comfort (R^2adj=0.28; p<0.045). Others could be predicted from the seat ratio, such as the abundance of tree shade (R^2adj=0.40; p<0.015), sophistication (R^2adj=0.36; p<0.015) and newness (R^2adj=0.34; p<0.028).

A logistic regression analysis was made using the raw data from the survey to predict users' satisfaction according to the tree ratio for the two activities: stay (Fig.5.) and rest (Fig.6.). The graph is divided into three areas: negative, neutral and positive impressions.

For this analysis, the 7-point scale was divided into three segments: -3, -2, -1 as negatives; 0 as neutral; and +1, +2, +3 as positives. This means that in the case of "place to rest", the answers "extremely agree", "agree" and "somewhat agree" to the survey prompt "hard to rest" are plotted as negative; "neither" is plotted as neutral and "extremely agree", "agree" and "somewhat agree" in response to the prompt "easy to rest" are plotted as positive.

The logistic regression makes it possible to evaluate the satisfaction rate with any density instead of relying on averages. Plotting results using logistic regression allows designers to use density values that will satisfy more than half of the users, which is extremely useful for data that vary from positive to negative impressions.

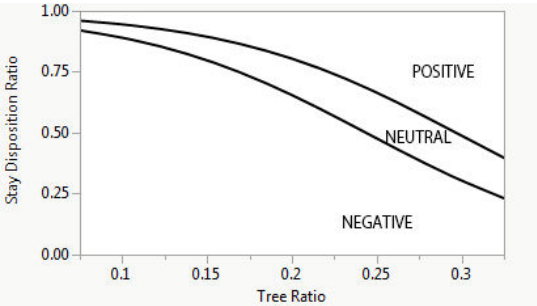

Fig.5. Logistic Regression of "Stay Duration" by Tree Ratio

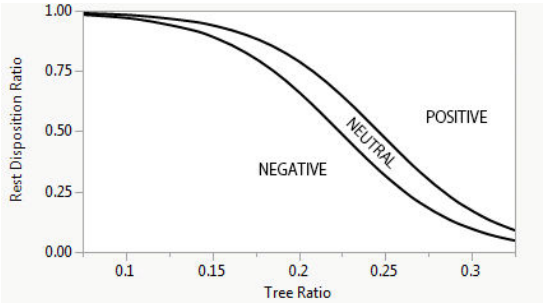

Fig.6. Logistic Regression of "Place to Rest" by Tree Ratio

3.2.2 Discussion

Both activity measurements in the SD survey could be predicted by tree ratio, which consisted of a broad range (from 10 to 30%) of the POPS area.

The seat ratio did not correlate with either the stay or rest activity. This may be because the seat ratio only varied from 0 to 3.4% of the total area. Considering that the seat ratio correlated well with the amount of greenery and abundance of tree shade, it is possible to assume that seat perception is related to tree placement and overall design. This could also explain the inverse correlation between the seat ratio and the newness and sophistication impressions.

It is worth noting that a negative correlation between the amount of bushes and organization exists (more bushes means a less organized space) because the number of bushes directly relates to the amount of greenery and overall space.

4. Conclusions

When asked to identify which physical elements caught their attention, participants pointed to basic elements: street furniture, greenery, buildings, sidewalk and overall space.

Greenery was the most cited physical element, and the tree ratio proved to be the best predictor of stay and rest activities. This result agrees with Tanaka & Kikata (2008) who related the amount of trees to rest activities and expands the results to include stay activities. In addition to trees, the amount of bushes correlated negatively with the impression of an organized space.

The most prominent impressions pointed out by users apart from emotional ones (e.g., goodness, liking and pleasantness) were *comfort* and *restfulness*; both highly correlated with the tree ratio.

Some of the characteristics expected to be found in the physical elements were also addressed in the present study such as *presence/absence* and *vegetation*, while others should be explored further in future research, particularly *placement*, *space composition* and *shape*.

A deeper study on the effects of hedges can profit from some *in loco* measures. A width x height measurement is probably more suitable for hedges instead of the flattened measure (depth x width) adopted in this study.

Further studies should also broaden the age group and include people from other fields of study to test education effect, which may lead to different results.

This study used all of the publicly accessible area of the lot to define the public space and instructed participants to explore the space as a whole. A more realistic measure would be to consider only those spaces that are perceived as a public space *a priori*, disregarding residual spaces such as back alleys, parking lots, service accesses and unloading docks that may be counted as public space in the FAR legislation but do not contribute to the public good, which will probably lead to more robust results to the findings described in this study.

Future studies can investigate impressions in other seasons to compare the effects of tree coverage and intended activity. Different climates, cultures, user profiles (e.g. age, necessities) and affordability could also yield different results that would be worth comparing.

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