#132

SELECTIVE ATTENTION WITHIN ISOVIST:

Changes In Viewers' Conceptual Understanding Of Architectural Elements Under Navigational And Exploratory Tasks

ANNA LOSONCZI
Hungarian Academy of Sciences, Budapest, Hungary
losonczi@ginkgoarchitects.com

ANETT RAGÓ
Eötvös Loránd University, Department of Cognitive Psychology, Budapest, Hungary
rago.anett@ppk.elte.hu

KLÁRA SARBAK
Ginkgo Green Architects, Budapest, Hungary
sarbakk@gmail.com

ANDREA DÚLL
Eötvös Loránd University, Department of Economical and Environmental Psychology, Budapest, Hungary
dull.andrea@ppk.elte.hu

SONIT BAFNA
Georgia Institute of Technology, School of Architecture, Atlanta, USA
sonit.bafna@design.gatech.edu

ABSTRACT

We report an experimental study investigating how changing vantage points and the context of viewing can lead viewers to shifts of attentional emphasis towards given architectural elements within an isovist, leading to different interpretations of these elements. We exposed a set of participants to interior views of the gallery space of Pulitzer Foundation for the Arts designed by Tadao Ando (St.Louis, US) that differed in vantage points and in a task context, and then asked them to register their impression of two prominent elements visible in the views—a long window and a parapet wall—and of the shape of the overall space of the gallery. Our results showed that the interpretations of the window changed with shifting viewpoints, but not those of the parapet. Nevertheless, we could manipulate the dominance of the potential interpretations by presenting different visual information and introducing different contexts. Our results indicate that while interpretations of objects may not change completely, the strength of the interpretations can increase and decrease significantly. We were also able to confirm that changes in viewpoints significantly changed the perception of the overall shape of the space. The broader aim behind this study was to learn what influences shifts in attention of what is available in the isovist, and how that can produce changes in aspects or interpretation of the seen objects. This kind of knowledge can help us understand how design decisions by architects influence not only the shape and size of isovists in buildings, but also what is actually registered by a viewer within them.

KEYWORDS

visual perception, spatial cognition, architectural aesthetics, design research, attention

1. RESEARCH TOPIC AND MAIN THEORETICAL ASSUMPTIONS

As a basic element in the syntactical description of space, the isovist has always been conceived of as being ecumenical with respect to what is actually registered by the situated observer (Peponis et al., 1997; Benedikt, 1979). And so what is captured in isovist, or field-of-view based metrics such as in Depthmap's VGA, are potential fields of view (Turner et al., 2002). The study we intend to present is part of a research based on investigating the difference between what is potentially available and what is actually registered by situated viewers, the premise being that the task that the viewers are engaged in would alter the salience of what they attend to within the visual field (Shiffrin, 1988; Mack and Rock, 1998). If some systematic qualities can be found in the change of relative salience of what is noticed, then subtler structural descriptions of spaces can be developed that are more sensitive to architectural qualities (Zook and Bafna, 2016).

Our study is a further development of ideas that we originally investigated in an experimental study in Bafna, Losonczi, and Peponis (2012). There, the main intention was to test if the changing of positions in a simple cuboidal volume would produce a systematic or predictable shift in visual attention[1]. The positions were differentiated by being placed within different e-partition spaces. E-partitions create regions that are by definition informationally stable, and any movement across an e-partition always results in a change in information (Peponis et al., 1997). The study found that shifts in visual attention were not simply associated with the information actually available in the isovist from the position selected, but was influenced by the path on which the position was located. The nature of attention could vary for the same position depending upon which path the position was associated with.

The present study investigates these issues further. The emphasis here is on how visual attention can pick-out different aspects of what is given in the isovist of a point location inside an architectural interior. The shift in attention, we think, should happen according to two distinct sets of factors, both working independently. The first factor is spatial location. As one moves within a building, and is attending consciously to it, he or she will be exposed to visual information about the building elements in different order (Eisenkolb, Schill, Röhrbein, Baier, Musto, and Brauer, 2000). If this is true then the observer is likely to attend to different attributes as his or her position changes; the position change creates a dynamic change in his or her attention. In a carefully designed building, the way in which this information is revealed can be carefully considered and is often treated as an aspect of the design itself (Bafna, 2013). Architecture, in a manner of speaking, turns buildings into machines designed to guide attention to themselves.

A second factor in controlling attention has to do with the fact that attention is purpose or task-dependent (James, 1890, 447-50). To attend to something is to attend to it as a part of a particular task or activity. If the attention is without purpose, then it becomes aimless and can quickly dissipate. In fact, work on inattentional blindness has shown that under certain tasks participants can actually be blind to very large objects in their visual fields (Mack and Rock, 1998). The specific type of attention we refer to here is focal visual attention. A form of attention that is associated with maintaining alertness has a different character altogether (Posner, 1994) and is not the subject of our study here. It follows that arming an observer with a specific task should have a notable effect on what he or she attends to in the space. Architects, it is true, cannot control the kinds of tasks visitors to their buildings may be occupied with, but insofar as they design buildings to be looked at and appreciated, it is useful to know how a purposeful visual examination of building can influence what is seen in the building.

1 We are using the term attention to refer exclusively to visual attention in this paper.

2. EXPERIMENTAL DESIGN

2.1 SET UP: ATTENTION TO ARCHITECTURAL ELEMENTS AND INTERPRETATIONS

In order to study the effect of both spatial location and the task-related context, we designed a study in which we exposed a set of participants to interior views of a large room, while they were placed under a variety of conditions related to both these factors.

The views were presented as 1800*1200 pixels images[2] of interior scenes obtained from a three-dimensional computer model of the gallery space in the Pulitzer Foundation for the Arts at St. Louis Missouri, designed by Tadao Ando. Ando's design for the interior of this room is very sparse, but with a very distinctive and unique organization. The room is very long (168 feet) and high (24 feet) for its width (24 feet), and features plain white walls and ceilings and a light grey floor. A few elements relieve the plainness of the entire space; these include 1) wide steps going down at one end, 2) leaving a narrow passage on one side at the same level along the main floor 3) a large, horizontal, glazed window running along the passage, 4) a low parapet along the passage, and 5) a hidden skylight at the far end. None of these elements is typical; all are ambiguous as to their function and character. Our aim was to see if exposing participants to views taken from particular viewpoints or having them involved in specific task-related conditions would lead them to attend to different aspects of these elements, or to see them in one way or another.

We collected data on two elements as well as on the overall understanding of the shape of the space as the participants saw it. The selection of the elements[3] and their potential interpretations used in the experiment was derived from a series of previous studies by the research group (cf. Losonczi et al., 2014 and 2015). One of the elements was the long window on the right side of the gallery space (Figure 1a). Sometimes it appears to be a long glass wall that brings light and can be interpreted as kind of a light-giving object or lightsource that is, as an object that provides light (in the questionnaire we used the Hungarian term *fényforrás*). In other views, it appears to be kind of an aperture or void cut out into the solid wall that is connecting up the inner and the outer spaces (in the questionnaire we used the Hungarian term *nyílás*). The other element was the low horizontal parapet that runs along the narrow passage next to the window. The parapet wall can be interpreted either as a wall that divides the space of the room into two parts, or as a slab placed on the floor of the bridge for safety[4].

We introduced one more feature of the design in our experiment to which participants had to respond, the space of the entire gallery. Focal attention to the building is not always narrowly focused on individual elements or parts of the building; it is also broadened to include an understanding of the entire space. The design of the room subtly alters the perception of its shape under different conditions. From some points of view, depth seems like a dominant dimension, and from others width or height do, and sometimes dominance may be shared by two dimensions. We wanted to test if the attention of the viewers would be sensitive to the shifts in such perceptions.

2 We used a photorealistic model of the gallery, created using Autodesk Revit Architecture (2011) and Autodesk 3ds Max Design (2011) to generate the views, rather than actual photographs of the gallery. The virtual model and the renders were produced with the help of Matthew Swarts, research scientist, School of Architecture, Georgia Institute of Technology.

3 We are investigating the role of the elements and their interaction with the space and the perception of the space (instead of investigating only the role of the whole space) in order to explore the possible consequences of each design decision separately. So as to designer architects can use the outcome of the research in a more efficient way. In our previous studies we found that the potential moves considered by the designers were all related to a small set of elements of an architectural setting (Losonczi et al., 2014).

4 There are no equivalent English terms to the Hungarian ones used in the experiment for the reading of the window. Therefore we give a description of the terms here (above) and we will use later on the following labels: "light-giving object" vs. "void/aperture" for the interpretations of the window. Labels for the interpretations of the parapet wall will be "slab+protection" vs "wall+division", labels used by virtue of simplification.

In this paper we were not interested in comparing the differences between the three items (window, parapet wall and entire space), but in checking to see if our hypotheses held across each of them independently. However, as we will discuss later, the perception of space is holistic and we had some general assumptions that users' perceptions of different aspects of the window and the parapet would be aligned with their perceptions of space.

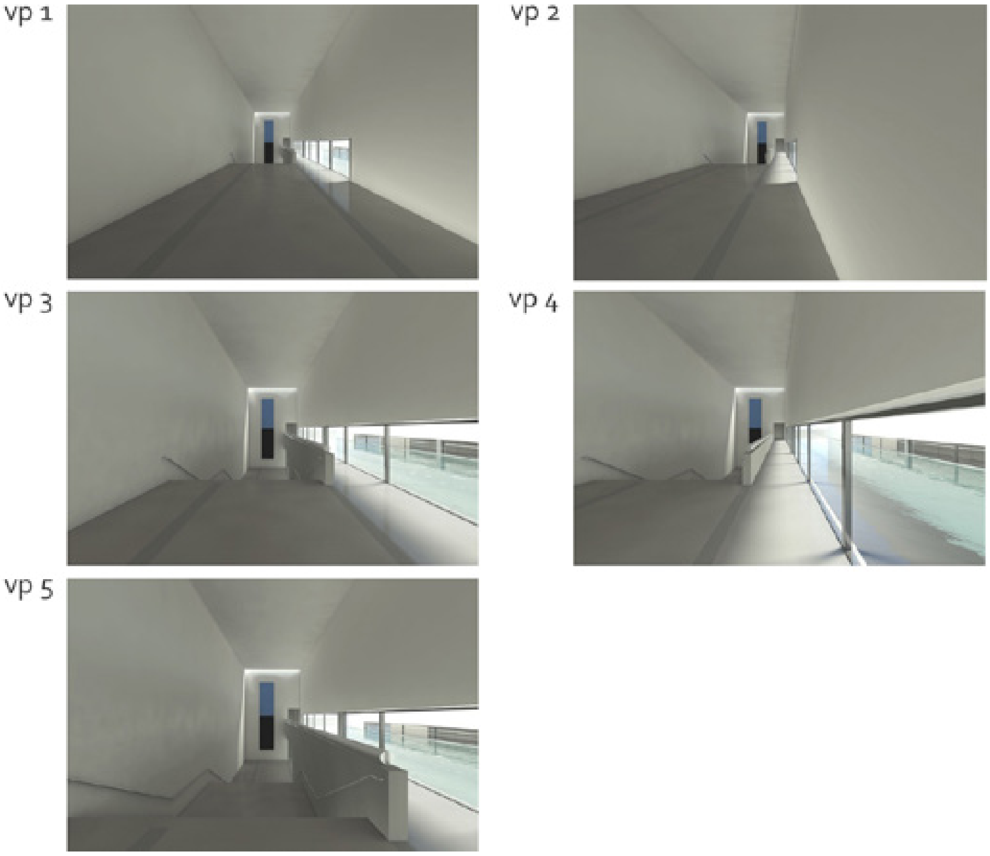

Figure 1a - Pulitzer Foundation for the Arts (St.Louis, USA) designed by Tadao Ando; Five vantage points used in the experiment[5]

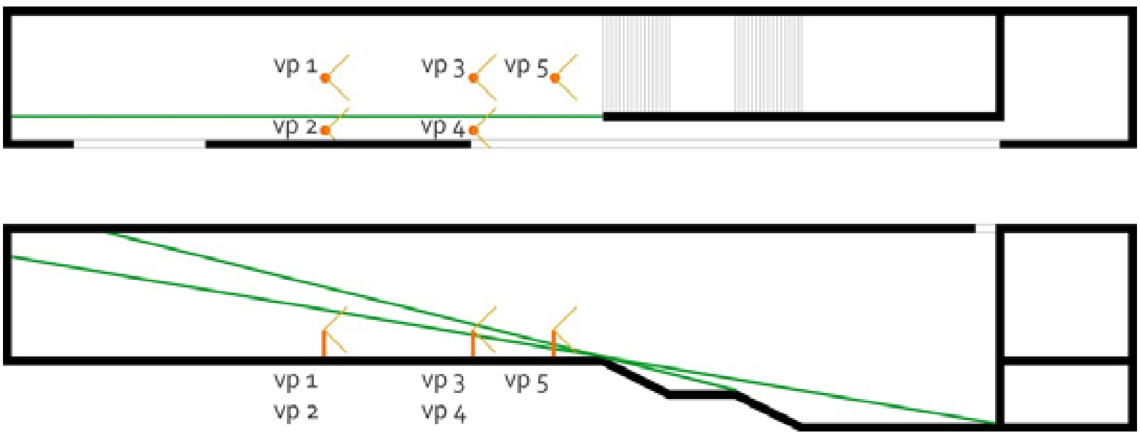

Figure 1b - Pulitzer Foundation for the Arts (St.Louis, USA) designed by Tadao Ando; Plan, section and the four vantage points used in the experiment

5 See footnote 2 above

2.2 EXPOSURE TO FACTOR 1: SHIFTS IN SPATIAL LOCATION

The exposure to the spatial location factor was created by selecting distinct vantage points from which rendered views of the room were generated. The views looked in the same direction, so assembling them in sequence suggested a path. Each participant was exposed to three vantage points for each item one after the other, as he or she considered responses to the window, the parapet wall, and the overall space. The vantage points and the three routes are illustrated on Figure 2. The route designed for the window-task is identical to the route used for the space-task; and have two vantage points that are identical with the first and third views of the parapet route.

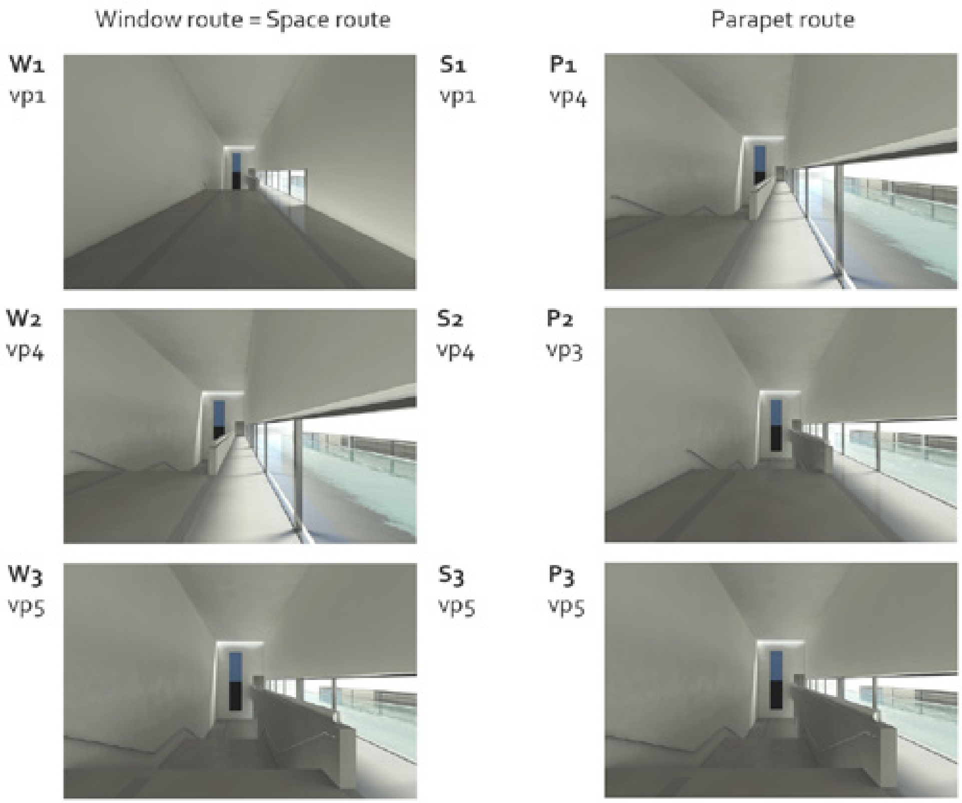

Figure 2 - Window set of views (W1, W2, W3); Parapet set of views (P1, P2, P3); Space set of views (S1, S2, S3)

For window, we hypothesized that from the first view (vantage point W1), the window appearing small and relatively opaque, and contrasting with the relatively dark gallery would appear more strongly like a "light-giving object". For the second view (vantage point W2), we hypothesized that it would show increased identification as a "void/aperture" as the viewer picked out the attributes like the absence of frame, the floor level as the sill level of the window, the unusual proportions of the window, and the solid wall. The third view (vantage point W3) showed both expanse outside, but with the visual interruption created by the parapet, we hypothesized that it would create ambiguity in identification.

For the parapet, we hypothesized that the first view (vantage point P1) would orient participants' attention to the difference at the floor level in the bridge-like space and the space on the other side of the low-height wall (parapet wall) along the bridge. And this focus would lead to an identification of the parapet wall as a low slab placed on the floor of the bridge for safety; "slab+ protection". From the second view (vantage point P2), when the other side of the parapet is appearing in the visual field, they would perhaps attend also to its surface-like quality and tend to see it both as a "wall+division" and "slab+protection". Then in the next view (vantage point P3), when they encountered the parapet next to the steps, its height and enclosing quality become more dominant and they tend to see it more likely as a wall dividing the space; "wall+division".

The hypotheses about how the overall space would be read from each vantage point were quite straightforward: "depth" was expected to be found as the dimension dominant in participants' perception for vantage point S1, "width" for vantage point S2, and "height" for vantage point S3.

2.3 EXPOSURE TO FACTOR 2: TASK-RELATED CONDITIONS

The varying exposure to the task related condition was created by constructing two narratives and asking the participants to perform a small task at the beginning and at the end of the exercise. In story A, the participants were asked to think of the room as a gallery where an exhibition is being held. Their task was to help the curator to find the place for 3 sets of antique paintings that are quite small in size with each set consisting of 6-8 pieces. Participants were asked to imagine themselves in the space showing the curator their suggestions about where to hang the paintings. In story B, the participants were asked to again consider as a setting for contemporary art in which an event consisting of an exhibition and an interactive dance performance was planned. Participants were tasked with helping to the curator find locations for 6 poster-like artworks printed on a semi-transparent and waterproof textile. The posters were described as being about 2 meters high and 3 meters wide each. Participants were also asked to find a place for those people who would want to observe the interactive event without participating actively in it. Participants were asked to imagine themselves in the space showing the curator their suggestions about where to hang the artworks and where to place the people. To create a comparative benchmark for the participants' attention we also created a control condition, in which the participants were not exposed to any task, but were simply asked to record their changing interpretation of the two elements and overall space with the change of vantage points.

The participants were divided into three groups, with each group being exposed to one of the task-related condition.

In case of story A we expected that the participants' attention would focus on the walls, their size, the light falling on them, and on distances from which "small-size" paintings are seen.

In case of story B, we expected the participants' attention to be distributed over the entire space, focusing not just on walls, but on the floors as well, and bringing into consideration views across the entire room. Because the posters to be located were transparent and large, participants had an opportunity to consider non-traditional hangings, say in the middle of the room, in the space outside the window etc., and because they were asked to accommodate passive and active observers, we expected them to think actively about primary and secondary spaces of the room (such as narrow passage next to the window, the space outside the window, the steps etc.) considering the spatial relations between them as well.

In comparison with the control condition, exposure to story A, therefore, was expected to result in increased identification with the window as "light-giving object", whereas exposure to story B was expected to result in a simultaneous identification of the window as both "light-giving object" and "void/aperture". The parapet was expected to be more strongly perceived as a "wall+division" by participants in condition A, and as a "slab+protection" in condition B.

2.4 PROCEDURE

2.4.1 PARTICIPANTS

93 adult participants were recruited for the experiment (mean age=26.1 years min.=20 max.= 55). Most of them were university students who got credits for participation. The number of participants per the three task-related conditions was balanced 30/30/33 participants for

stories A and B and the control condition C respectively. The age, sex, and profession[6] of the participants were matched in case of the three task-related conditions.

As described above, different groups of participants were exposed to different task-related conditions, but within each group, each participant was exposed to all three sets of vantage points as each participants were asked about all the three items — the two building elements and the overall space.

The survey was conducted through an online electronic interface in Hungarian language. At the beginning of the survey 5 views of the space were presented to the participants, they were asked to study them and to become familiar with the room presented. In the same page of the survey the participants were given the description of the imaginary situation (the stories A and B) that included a task. Participants were asked to keep the task in mind during filling the questionnaire. It was optional to give a comment/answer on this page and participants were told that they will be asked again about the same task at the end of the questionnaire. The aim was to keep the task active in the mind of the participants as they answered the question. The task (especially in case of story B) was not easy to solve. We supposed that participants doing their imaginary walks in the space will be searching for specific information being able to do the task. So thus participant groups (A, B) will be aware of slightly different information according to the stories (A, B) given on the first page of the survey.

After this section participants were asked about potential interpretations of the window and the parapet wall. The interpretations of both elements had to be considered one by one by the 2X3 vantage points linked to the elements (3 vantage points to each, according to the theory described above). Each vantage point of the window set was linked to the same question "How well do the following phrases describe the long window on the right side of the room?" Participants were asked to rank the following answers 1. "A light-giving object" (1: Not at all - 7: Very well); 2. "A void/aperture connecting to the outside" (1: Not at all - 7: Very well); and they were asked to give an optional answer in case they were thinking about another phrase describing the window better. The questionnaire of the parapet wall section was designed similar way. Each vantage point of the parapet wall set was linked to the same question "How well do the following phrases describe the parapet seen in the middle of the room?" Participants were asked to rank the following answers 1. "A wall that divides the space of the room into two parts" (1: Not at all - 7: Very well); 2. "A slab placed on the floor of the bridge for safety" (1: Not at all - 7: Very well); and they were asked to give an optional answer in case they were thinking about another phrase describing the parapet wall better.

Questions about the perceived shape of the entire space followed. Participants were asked to imagine themselves standing in the art room and asked about their perception of the space seen in the pictures presented to them. We suggested that "the space can be described as extending in three dimensions: 1. Along a vertical axis, extending up or down, parallel to a standing human body, 2. Along a horizontal axis parallel to the plane of the picture, extending left or right , and 3. Along a horizontal axis extending in depth away." Participants were asked the same questions about each views of the Space route and were asked to choose one of the 4 options: "For each picture you see, along which one of the three dimensions do you feel the space extends most strongly? 1. Depth (extending into or out of picture plane); 2. Width (extending left or right parallel to the picture plane); 3. Height (extending vertically up or down); or 4. No dominant dimension".

6 We assume that space-competence matters in the process how visitors (participants of the experiment in this case) read an architectural setting.
In further analysis we are interested in how architects and human experts are different in so elementary functions like spontaneous visual attention. In this paper, we do not analyze neither gender differences, nor divergencies between architects and non-architects.

3. ANALYSIS PROCEDURE

As we explain the analysis procedure the reader may find it useful to keep in mind the summary of raw scores obtained from the entire experiment. See Table 1.

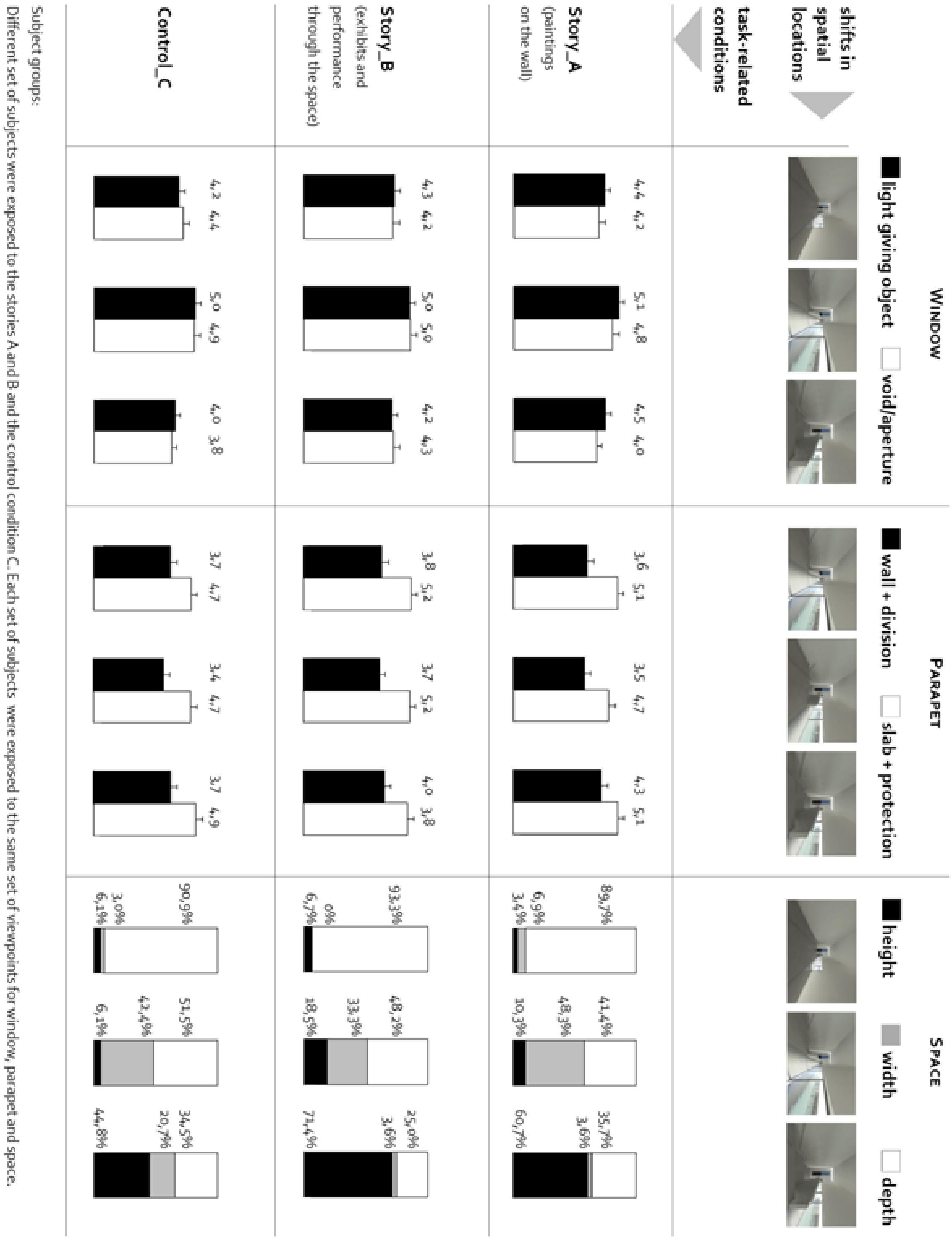

Table 1 - Summary of raw scores obtained from the entire experiment

We analyzed the (absolute or relative) change of the interpretations according to the shifts of spatial locations (viewpoints) in case of the window and the parapet across the three task-related conditions.

We conducted four types of analyses which focused on different aspects of the results (we only report statistically significant results)[7]:

1. To get a general view of the effects of the experimental manipulations (task-related conditions; viewpoints; offered interpretations) and the interaction of the manipulated factors we used the original 7-scale-scores and ran the following statistical analyses on them separately for the two spatial objects (window and parapet). To be able to see the effect of the two types of manipulations (within- vs. between-subject variables) in general, we ran a 3x2x3 mixed ANOVA where the two repeated-measure factors (within-subject variables) were the three viewpoints and the two interpretations "light-giving object" vs. "void/aperture" for the window and "slab+protection" vs "wall+division" for the parapet. When the sphericity criterion was unfulfilled we applied the Greenhouse-Geisser correction. The independent variable (between-subject variable) was the task-related condition (3 levels). As a post-hoc test for the between-subject effect we applied the Bonferroni calculation.

2. We were also interested in the relative difference between the two interpretations of the objects so we converted the subjects' scores for each of the two elements into dichotomous variables: for each interpretation therefore, if the subjects' score was larger, the value of the variable assigned was 1 and if it was smaller the value assigned was zero. . If the two scores were equal both of the interpretation variables were assigned zeros. Using these dichotomous variables as response variables, we ran Wilcoxon signed ranks tests for each of the three viewpoints in the three task-related conditions separately. As it is not possible to use such non-parametric tests to conduct ANOVA type of factorial analyses, the differences between task-related conditions can only indirectly signify the different background processes. However, we see this kind of calculation as being more sensitive in capturing the dynamics of the viewpoint changes. This kind of analysis was suitable for determining the actual dominance of one interpretation over the other in case of the two objects.

3. Similar relative variables were calculated for determining the change of interpretations between the three viewpoints. When the subjects' interpretive scores were bigger in viewpoint 1 compared to viewpoint 2 we marked viewpoint 1 as having the value 1, and viewpoint 2 as zero. When the two scores were equal we marked both variables as zero. This coding was repeated for viewpoint 2 versus 3. We ran Wilcoxon signed ranks tests on the four variables for each interpretations in the three conditions separately. The four variables come from comparing changes in the successive viewpoints (variable 1 is when scores for viewpoint 1 is greater than for viewpoint 2; variable 2 is when scores for viewpoint 2 is greater than for viewpoint 1; variable 3 is when scores for viewpoint 2 is greater than for viewpoint 3; variable 4 is when scores for viewpoint 3 is greater than for viewpoint 2). All the limitations we describe in the second point (ii) above for non-parametric tests are valid here too. But again, the advantage of these calculations here is to show the possible dynamic change of interpretations due to the viewpoint changes.

4. Since the vantage points used for the overall space (S1, S2, S3) were identical to those of pictures representing the three different viewpoints (W1, W2, W3) in case of the window it seems reasonable to match the participants' interpretations for the overall space to the relative dominance of any of the interpretations for the window. For these types of analyses we created another transformation on the original raw scores. We recoded the original responses within each interpretations according to the following rule: those

7 The statistical analyses that we refer to below are standard tests for hypothesis-testing—variants of ANOVA or Chi-Square, as well as some of their non-parametric analogues. For the readers not familiar with such tests, a glossary appended at the end of the paper gives their definitions, as well as those of the corrections that we applied, and sources for learning about them further.

scores that were below 5 were recoded into value zero (interpretation-low), and the scores above 4 were recoded into value 1, (interpretation-high) In consequence, we had two dichotomous interpretation variables ("light-giving object" low-high, "void/aperture" low-high) for the three viewpoints. We with a help of chi-square tests could compare the distribution of the low-high values to the distribution of the three spatial dimensions ("height"/"width"/"depth"). Here the main question was whether the dominance of an interpretation (e.g. high values for the "light-giving object" interpretation) correspond to the dominance of any of the three spatial dimensions within the actual vantage point (e.g. the dominance of "height" values within S1)

4. RESULTS

1. In case of the window the 3x2x3 mixed ANOVA produced a significant main effect of the viewpoint $F(2,180) = 41.24$ $p > .001$ $\eta 2^2 = .31$. Neither the other main effect (interpretation), nor the interactions were significant, and nor was the between-subject effect for the task-related conditions.

   Based on the contrast analyses we can state that the significant effect was caused by the overall increase of the values for both functions in case of the viewpoint 2 compared to the two other viewpoints (viewpoint 1 vs viewpoint 2: $F(1, 90) = 49.81$ $p < .001$ $\eta 2 = .36$. viewpoint 2 vs. viewpoint 3 $F(1, 90) = 68.51$ $p < .001$ $\eta 2 = .43$.). Figure 3 demonstrates this change in general, for all task-related conditions.

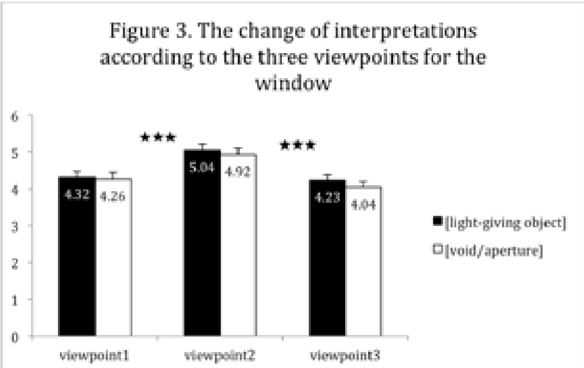

Figure 3 - Average value changes for the two interpretations according to the three viewpoints in all task-related conditions. Whiskers represent standard error values. Stars represent the value of significance ($p < .001$).

In case of the parapet the 3x2x3 mixed ANOVA produced a significant main effect for the interpretation variable $F(1,90) = 33.22$ $p < .001$ $\eta 2 = .27$. Neither the other main effect (viewpoint) or interactions were significant, nor the between-subject effect for the task-related conditions.

According to the contrast analyses we can state that the significant effect was caused by the bigger average scores for the "slab+protection" interpretation in general. This difference was stable across viewpoints and task-related conditions. Figure 4 demonstrates this change in general, independently of the type of the task-related conditions.

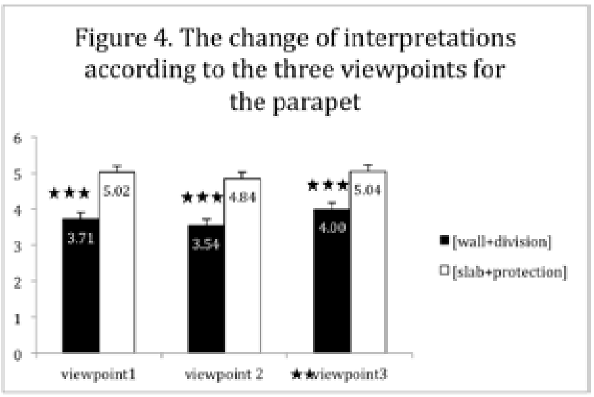

Figure 4 - Average value changes for the two interpretations according to the three viewpoints in all task-related conditions. Whiskers represent standard error values. Stars represent the value of significance according to the following rule: ***$p < .001$ **$p < 01$.

As figure shows contrast analyses revealed another significant result: the averaged values for both interpretations were bigger in case of viewpoint 3 compared to viewpoint 2 $F(1,90) = 10.27$ $p < .01$ $\eta 2 = .1$.

2. In case of the window we found significant differences between the two interpretations in the story A condition in viewpoint 2 ($Z = -1.96$ $p < .05$). This difference was caused by the dominance of the "light-giving object" interpretation over the "void/aperture" interpretation. In general, the "light-giving object" interpretation did get bigger scores according the absolute value-calculation but if we focus on the differences between the two interpretations we see a significant dominance of the "light-giving object" interpretation in condition A in viewpoint 2.

   Figure 5a shows this relative difference of the two interpretations under the condition of story A in viewpoint 2.

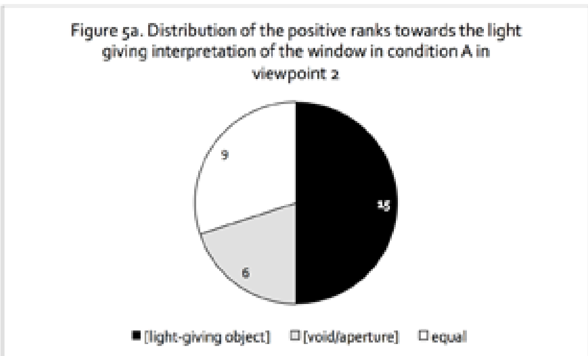

Figure 5a - The relative dominance of the "light-giving object" interpretation of the window in task-related condition A based on the Wilcoxon signed ranks test. Numbers are representing the number of ranks towards the given interpretation, and the cases when both values were equal.

To be able to compare this relative calculation with the original, absolute one we present a similar visualization for the mean values for the dichotomous variables related to the possible dominance of one of the two window interpretations (see Figure 5b).

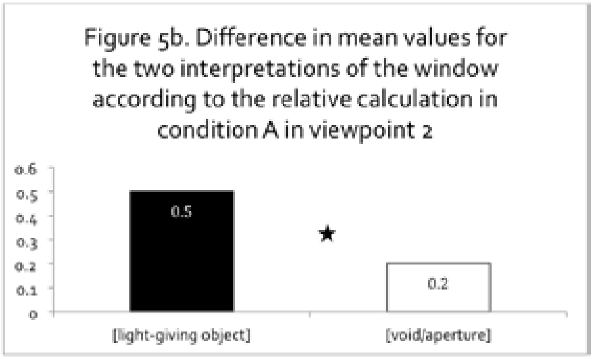

Figure 5b - Mean values in case of the relative calculation for the dominance of one of the two window interpretations.
(= p < .5)*

In case of the parapet the dominance of the "slab+protection" interpretation was present also in the non-parametric test so the Wilcoxon signed ranks tests in each viewpoint were significant (Viewpoint 1 Z = -4.23 p < .001; Viewpoint 2 Z = -4.22 p < .001; Viewpoint 3 Z = -3.01 p < .01). These significant effects were also present in all conditions separately except the task-related condition A where the dominance of the "slab+protection" interpretation was not significant in Viewpoint 3[8].

Figure 6a shows this stable dominance towards the "slab+protection" interpretation in each viewpoints in all task-related conditions.

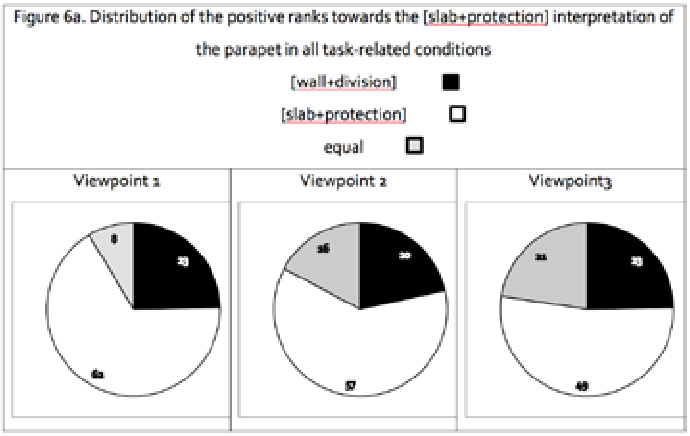

Figure 6a - The relative dominance of the "slab+protection" interpretation of the parapet in each viewpoints separately, in all task-related conditions based on the Wilcoxon signed ranks test. Numbers are representing the number of ranks towards the given interpretation, and the cases when both values were equal.

Here we also present another visualization of the results as we did in case of the window. Figure 6b shows the differences of the mean values of the dichotomous variables in case of each viewpoint in all task-related conditions.

8 This later result is important as it shows the validity of this calculation: the significant difference between the two viewpoints in case of the parapet in the original calculation was probably caused by this difference in the distribution of the values according to the two interpretations.

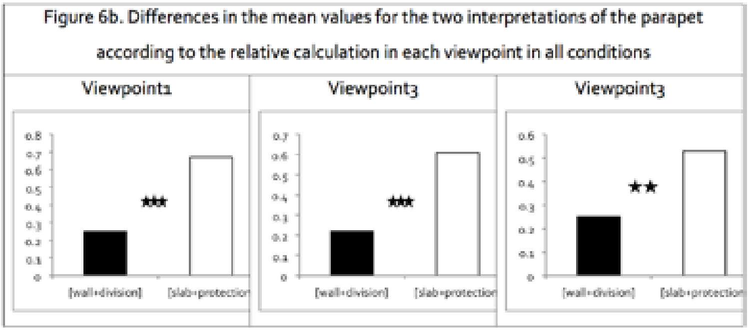

Figure 6b - Differences in the mean values for the two interpretations of the parapet according to the relative calculation in each viewpoint in all conditions. Stars represent the value of significance according to the following rule: ****p* < *.001* ***p*< *01.*

3. In case of the window we got the same impact of the viewpoint as we saw before as in case of both interpretations in viewpoint 2 got more ranks compared to viewpoints 1 and 3.

   In case of the parapet this analysis showed something extra: the increase of the "wall+division" interpretation was present only in condition A when viewpoint changed from 2 into 3

   (Z = -2.98 $p < .01$).

4. A Friedman test revealed significant differences between the mean ranks of the three views encountered for the questions for space (Vantage points S1, S2, S3) $\chi 2$ (2) = 60.07 p < .001. In case of the first view (Vantage point S1) the "depth" answers were dominant, in case of second view (Vantage point S1) both "depth" and "width", and in case of the third view (Vantage point S1) the "height" answers were dominant. The chi-square tests were significant only in case of the second vantage point (S2) where the "void/aperture" interpretation in got significantly more "width" answers for the space questions. On the contrary, those subjects who gave bigger scores to "void/aperture" interpretation in the same situation, also found the space to be significantly to be more associated with the "height" dimension ($\chi 2$ (2) = 7.18 $p < .05$; see Figure 7.) This double dissociation seems to represent the same underlying process.

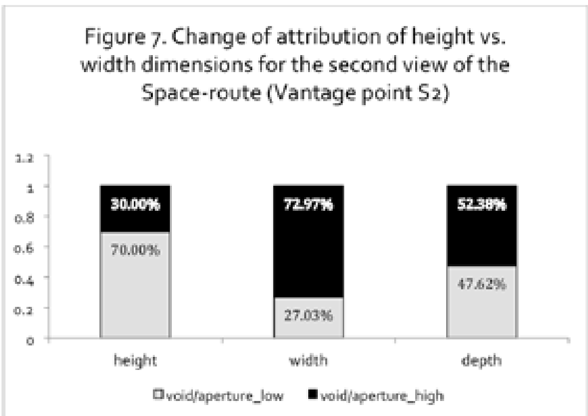

Figure 7 - Differences in the mean values for the two interpretations of the parapet according to the relative calculation in each viewpoint in all conditions. Stars represent the value of significance according to the following rule: ****p* < *.001* ***p*< *01.*

5. DISCUSSION

5.1 EFFECTS OF THE CONDITIONS

In this study our aim was to investigate how the changes in salience of visual information created either by being pre-occupied in a specific task, or simply changing position within the environment can create different interpretations of the elements of an architectural environment. Our results showed that both our exposure factors did create some change in interpretation, but differently for the two elements.

In case of the window there was a significant change in the strength of both interpretations[9]. In case of the parapet wall however, the strength-values were more stable. We found that one of the interpretations of the parapet wall – ("slab+protection") - was more likely to be dominant throughout[10]. However in case of the window the strength of both interpretations were generally similar. These characteristics of the elements did not change by viewpoints.

We also did not find a significant main effect for the second factor — task-related context, but results showed that for specific locations task A had a stronger effect on the participants. The result supports the idea that the effect of task-related conditions is to focus attention on particular attributes. Task A, for instance, would have led the participants to focus attention specifically on wall-surfaces, their enclosing quality, relative illumination, and their visibility closely, as the participants decided where to place pictures on the walls. Task B, on the other hand, could have created a more diffuse attention because it asked the participants to keep a more complex and larger set of attributes in mind, as they figured out how to locate people and how to hang large translucent posters within the space of the gallery considering potential cross-views as well[11].

5.2 SHIFTS BETWEEN THE INTERPRETATIONS

Our results did not confirm the assumption that interpretations can change completely with changes in either location or task-related context. This could be caused by the heterogeneity of participants' answers. They differently used the 7-point scale, and also, were not equally sensitive to the differences between the two interpretations. Furthermore, there were cases when the consensus was lower. This question needs further modifications of the experimental design.

Our results indicate that while interpretations of objects may not change completely, the *strength* of the interpretations can increase and decrease significantly, and in the predicted direction, with both locations and task-related context. And because the two interpretations can co-exist in the mind of the participants, the shifts in the strength of their interpretation can be independent of each other. For instance in case of the window at the second viewpoint (general task-related condition), the strength of both interpretations significantly increased compared to the ones at the first and third viewpoints. Similarly, in case of the parapet wall, one of the analysis shows a significant increase of the strength of the interpretation as "wall+division" and a stability of the strength of the interpretation as "slab+protection" that results in a higher level of ambiguity in readings. That leads to the assumption that even elements with stable interpretation can be modified to be more ambiguous in specific conditions.

9 Both interpetations of the window - "void/aperture" and "light-giving object" - had significantly larger values for viewpoint 2 as compared to viewpoints 1 and 3.

10 The differences between the strength of the interpretations of the parapet wall - "wall+division" and "slab+protection" - were significant in case of all views in all task-related conditions (except in case of task-related condition A viewpoint 3).

11 Participants were asked to respond to the verbal tasks in a descriptive way. Qualitative analysis of the verbal data supports the assumption that Task B made participants to understood and used the space in a more creative way than in case of Task A.

5.3 ARCHITECTURAL ASPECTS

We included the questions about the perception of the entire space in order to extend the research to a topic that is more likely meets with the interest of designer architects. We assume that the interpretations of the elements of an architectural setting contribute to the overall reading of the space. For instance the window being read as "void/aperture" and the parapet being read as "slab+protection", instead of a surface dividing the space - "wall+division" - can contribute to the perception of the width of the space as the dominant dimension. We assume that the synchronized effects on interpretations can lead to a particular architectural quality. Results supported our hypothesis that the space was perceived as being stronger in "width" dimension when the window was read as "void/aperture"[12].

5.4 RESEARCH OF CATEGORIZATION

While this paper does not focus on specific theories of categorization, its approach gives the opportunity to continue investigating specific types of interpretations that are more likely exclusive and understand them as categories. If we think of these interpretations as labels of the functional categories of these spatial objects then the relative difference between the two interpretations should be highlighted. We found evidence for the differentiation between the two interpretations even in this setting where we let the participants use the scales independently from each other. This raises the question, what happens if we ask them to choose between the two interpretations focusing on one aspect of the object. This approach might reflect better the dynamic nature of understanding the objects via moving in the space. We know from earlier studies that categories are flexible (Barsalou, 1983), and that objects labels have an impact on category decision (cf. Fulkerson and Waxman, 2007). At the same time we also know that the original label can influence the categorization of an object (cf. Bloom, 1996; Kelemen, 2004). It is our next theoretical question whether spatial objects behave as cultural artifacts and so their form and original use give the dominant interpretation which is culturally different or the space and the movement in the space make categorization more flexible.

12 Participants who gave higher rates for "void/aperture" considered the perception of the width of the whole space more important, and similarly participants who gave lower rates for "void/aperture" considered the perception of the height of the whole space more important. These results seem to support the same - assumed - underlying process.

REFERENCES

Bafna, S., Losonczi, A., & Peponis, J. (2012). Perceptual tuning of a simple box. In Greene, M., Reyes, J. and Castro, A.(eds.) *Proceedings of the 8th International Symposium on Space Syntax*, 8024, pp. 1-28.

Bafna, S. (2013). Attention and imaginative engagement in Marcel Breuer's Atlanta Public Library. In Bhatt, R. *Rethinking aesthetics. The role of body in design*. Routledge, New York. pp. 51-84.

Barsalou, L. W. (1983). Ad hoc categories. *Memory & cognition*, 11 (3), pp. 211-227.

Benedikt, M. (1979). To take hold of space: Isovists and isovist fields. *Environment and Planning B: Planning and Design*, 6, pp. 47-65.

Bloom, P. (1996). Intention, history, and artifact concepts. *Cognition*, 60 (1), pp. 1-29.

Eisenkolb, A., Schill, K., Röhrbein, F., Baier, V., Musto, A., and Brauer, W. (2000). Visual processing and representation of spatio-temporal patterns. In Freksa, C. et al. (eds.): *Spatial Cognition II*, LNAI 1849, pp. 145–156.

Fulkerson, A. L., & Waxman, S. R. (2007). Words (but not tones) facilitate object categorization: Evidence from 6-and 12-month-olds. *Cognition*, 105 (1), pp. 218-228.

James, W. (1890). *The principles of psychology*. New York: Holt. pp. 447-450. Retrieved from http://archive.org/details/theprinciplesofpo1jameuoft

Kelemen, D. (2004). Are children "intuitive theists"? Reasoning about purpose and design in nature. *Psychological Science*, 15 (5), pp. 295-301.

Losonczi, A., Ragó, A., Sarbak, K., Kurucz, A., Gulyás, L., & Dúll, A. (2016). The role of categorization in the cognitive process of a person moving in an interior space. *Poster presented at 39th European Conference on Visual Perception*, Barcelona.

Losonczi, A., Kurucz, A., Gulyás, L., Sarbak, K., & Dúll A. (2015). Capturing designers' intuitions of effects of formal design moves on user perception. *Poster presented at 10th International Space Syntax Symposium*, London.

Losonczi, A., Gulyás, L., Sarbak, K., Kurucz, A., Dúll, A., Bafna, S. (2014) Variety of percepts according to the spatial and temporal context in built environment. Presented at 23. IAPS (International Association of People-Environment Studies) Conference, Timisoara.

Mack, A., &Rock, I. (1998). *Inattentional Blindness*. Cambridge MA: MIT Press

Peponis, J., Wineman, J., Rashid, M., Kim, S.H., & Bafna, S. (1997). On the description of shape and spatial configuration inside buildings: Convex partitions and their local properties. *Environment and Planning B: Planning and Design*, 24, pp. 761-781.

Posner, M. I. (1994). The Mechanisms of Consciousness. *Proceedings of the National Academy of Sciences of the United States of America*, 91 (16), pp. 7398–7403.

Shiffrin R M. (1988). Attention. In Atkinson, R. C., Lindzey, G., & Luce, R. D. (eds.) *Handbook of Experimental Psychology*, 2, pp. 738-811. New York: Willey.

Turner, A., Doxa, M., O'Sullivan, D., & Penn, A. (2002). From isovists to visibility graphs: A methodology for the analysis of architectural space. *Environment and Planning B: Planning and Design*, 28, pp. 103-121.

Zook, J., &Bafna, S. (2016). The feel of space: social and phenomenal staging in Seattle Public Library. In: Dalton, R. C., & Hölscher, C. (eds.) *Take One Building: Interdisciplinary Research Perspectives of the Seattle Central Library*. Milton Park, Abingdon, Oxon ; New York, NY: Routledge. pp. 95-112.

APPENDIX

GLOSSARY OF STATISTICAL TESTS USED IN THE STUDY

The definitions listed here are adapted from several sources, as noted below. The text has been edited for relevance and context. Readers not familiar with these tests or those wishing further information will find it in standard textbooks on the subject. Alan Agresti, Categorical Data Analysis (3rd edition, 2013) is a common useful reference.

ANALYSIS OF VARIANCE (ANOVA)

Analysis of variance (ANOVA) is a collection of statistical models used to analyze the differences among group means and their associated procedures (such as "variation" among and between groups). In the ANOVA setting the observed variance in a particular variable is partitioned into components attributable to different sources of variation. ANOVA provides a statistical test of whether or not the means of several groups are equal[13].

BONFERRONI CORRECTION

The contrast analyses in case of repeated-measures ANOVA break down the main effect inform us about where the differences between the groups lie. A similar calculation for the between-subject variable is the post-hoc test. In case of variables of more than 2 values it run pairwise comparisons to be able to reveal whether there are significant differences between all the levels. In the IBM-SPSS software we can choose between two types of analyses. One of them is a Bonferroni correction we preferred here[14].

CHI-SQUARE TEST

A chi-squared test is any statistical hypothesis test wherein the sampling distribution of the test statistic is a chi-squared distribution when the null hypothesis is true. Chi-squared tests are often constructed from a sum of squared errors, or through the sample variance. A chi-squared test can be used to attempt rejection of the null hypothesis that the data are independent. The chi-squared test is used to determine whether there is a significant difference between the expected frequencies and the observed frequencies in one or more categories[15].

FRIEDMAN TEST

The Friedman test is the non-parametric alternative to the one-way ANOVA with repeated measures. It is used to test for differences between groups when the dependent variable being measured is ordinal. It can also be used for continuous data that has violated the assumptions necessary to run the one-way ANOVA with repeated measures (e.g., data that has marked deviations from normality)[16].

13 adapted from: Analysis of variance. (2017, April 17). In *Wikipedia, The Free Encyclopedia*. Retrieved 17:25, April 25, 2017, from https://en.wikipedia.org/w/index.php?title=Analysis_of_variance&oldid=775807211

14 Field, A. (2009). *Discovering statistics using SPSS*. Sage publications.

15 adapted from: Chi-squared test. (2017, March 28). In *Wikipedia, The Free Encyclopedia*. Retrieved 17:37, April 25, 2017, from https://en.wikipedia.org/w/index.php?title=Chi-squared_test&oldid=772664938

16 adapted from: Friedman test. From: https://statistics.laerd.com/spss-tutorials/friedman-test-using-spss-statistics.php

MAUCHLY'S SPHERICITY TEST

Sphericity is an important assumption of a repeated-measures ANOVA. It refers to the condition where the variances of the differences between all possible pairs of within-subject conditions (i.e., levels of the independent variable) are equal. The violation of sphericity occurs when it is not the case that the variances of the differences between all combinations of the conditions are equal. If sphericity is violated, then the variance calculations may be distorted, which would result in an F-ratio that would be inflated[17].

WILCOXON SIGNED-RANK TEST

The Wilcoxon signed-rank test is a non-parametric statistical hypothesis test used when comparing two related samples, matched samples, or repeated measurements on a single sample to assess whether their population mean ranks differ (i.e. it is a paired difference test). It can be used as an alternative to the paired Student's t-test, t-test for matched pairs, or the t-test for dependent samples when the population cannot be assumed to be normally distributed. A Wilcoxon signed-rank test is a nonparametric test that can be used to determine whether two dependent samples were selected from populations having the same distribution[18].

17 adapted from: Mauchly's sphericity test. (2017, March 15). In *Wikipedia, The Free Encyclopedia*. Retrieved 17:34, April 25, 2017, from https://en.wikipedia.org/w/index.php?title=Mauchly%27s_sphericity_test&oldid=770485807
18 adapted from: Wilcoxon signed-rank test. (2017, April 25). In *Wikipedia, The Free Encyclopedia*. Retrieved 17:37, April 25, 2017, from https://en.wikipedia.org/w/index.php?title=Wilcoxon_signed-rank_test&oldid=777163157