Introduction

The perspective drawing is one of the most effective presentation tools among the two-dimensional representation, conveying the prospective image of the architecture and spaces. The ultimate goal of the research is to understand the perception of the two-dimensional perspective images representing architecture and spaces in various frameworks, scales and compositions. As the initial stage, this paper specifically focuses on the Western paintings as a case study of the spatial representation in broader frameworks. Many techniques of the two-dimensional space representation, such as mathematical perspective methods, were originally developed for the paintings. It may be presumed that the perspective images, which we consider as the “accurate” representation of the space, give different senses from what we feel from the actual sight, through the drawing techniques as well as the painted elements and their composition.

Also, the two-dimensional spatial representation includes not only the visualization of the stand-alone architecture as an object, but also the way it appears with its surrounding environment and landscape. In this case, architecture, among the other elements, become one of the visual components, and their interrelationship represents “space” as a whole.

In this study, the psychological evaluation experiment based on the SD-method (Semantic Differential) was conducted, in order to quantitatively analyze the reception of the painted spaces, composed of the architecture and other elements. Based on the results, the spatial structure in Western paintings is analyzed to comprehend the way the common perception and images of the space are being formed. Through the understanding of the integral spatial images of architecture and environment in two-dimensional representations, this paper aims to gain some fundamental insights into the better measures for the future architectural representation.
Selection of the Surveyed Paintings

The 15 paintings (Tab. 1) were selected as the subject of the experiment through the following procedure (Fig. 1). First, the representational painting between the periods of Late Renaissance, when the mathematical perspective drawing method was established, and the Modern age were listed from the leading art history textbooks\(^1\) in Japan and the U.S. Although the interior space is an important part of the architectural spaces, the depictions of the interior and exterior space have considerably different characters, thus, this paper focuses on the exterior view of architecture as one of the visual components of space. The exterior views of the architecture include various cases, such as close-ups of parts of the buildings as well as groups of buildings in the background. The religious paintings are excluded because they are based on particular symbolism. Considering the final goal of the research to relate to the architectural drawing, the paintings over B0 size (1030 x 1456 mm) were omitted. Out of 39 selected paintings, for the purpose of this paper as a case study, 15 paintings are randomly chosen from different time periods.

Table 1. List of Surveyed Paintings

<table>
<thead>
<tr>
<th>Title</th>
<th>Abbr</th>
<th>Painter</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Tempest</td>
<td>TEM</td>
<td>Giorgione da Caselfranco</td>
<td>1510</td>
</tr>
<tr>
<td>The Judgement of Paris</td>
<td>JOP</td>
<td>Lucas Cranach the Elder</td>
<td>1528</td>
</tr>
<tr>
<td>The Blind Leading the Blind</td>
<td>BLB</td>
<td>Peter Bruegel the Elder</td>
<td>1568</td>
</tr>
<tr>
<td>Pelkus gate near Utrecht</td>
<td>UTR</td>
<td>Jan van Goyen</td>
<td>1646</td>
</tr>
<tr>
<td>A Pastoral Landscape</td>
<td>PAS</td>
<td>Claude Lorrain</td>
<td>1648</td>
</tr>
<tr>
<td>Bleaching grounds near Haarlen</td>
<td>HAA</td>
<td>Jacob van Ruisdael</td>
<td>1670</td>
</tr>
<tr>
<td>Mezzetin</td>
<td>MEZ</td>
<td>Jean Antoine Watteau</td>
<td>1718</td>
</tr>
<tr>
<td>The Gleaners</td>
<td>GLE</td>
<td>Jean Francois Millet</td>
<td>1857</td>
</tr>
<tr>
<td>On the Bank of the Seine</td>
<td>SEI</td>
<td>Claude Monet</td>
<td>1868</td>
</tr>
<tr>
<td>Max Schmitt in a Single Scull</td>
<td>MAX</td>
<td>Thomas Eakins</td>
<td>1871</td>
</tr>
<tr>
<td>Snap the Whip</td>
<td>STW</td>
<td>Winslow Homer</td>
<td>1872</td>
</tr>
<tr>
<td>The Sacred Grove</td>
<td>GRO</td>
<td>Pierre Puvis de Chavannes</td>
<td>1884</td>
</tr>
<tr>
<td>La Place du Theatre Francais</td>
<td>PTF</td>
<td>Camille Pisarro</td>
<td>1898</td>
</tr>
<tr>
<td>Mystery and Melancholy of a Street</td>
<td>MMS</td>
<td>Giorgio de Chirico</td>
<td>1914</td>
</tr>
<tr>
<td>American Gothic</td>
<td>AGO</td>
<td>Grant Wood</td>
<td>1930</td>
</tr>
</tbody>
</table>

Source: Kiwa Matsushita, Hiroshi Tsumita.

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The reception of the two-dimensional representation presumably depends on the viewer’s cultural background and age. In this experiment, the architectural students in Japan were chosen to be the research participants for the following two reasons. First, they are accustomed to view two-dimensional spatial representation and have more vocabularies to describe it than a layman. Secondly, Japanese architecture students are generally not so familiar with Western paintings and the most of them have never seen the subject paintings, so that it can be expected that their reception on the composition and structure of elements is straightforward without bias.

Analysis of Psychological Evaluation Based on SD-Method

To investigate what types of composition of the paintings influence their psychological evaluation and perception of space, the experiment based on the SD (Semantic Differential) method was conducted. Originally devised to measure the meaning of words, the SD-method has been adopted to the research of Architecture and Space as one of the widely used methods to quantitatively measure various psychological evaluations of spaces. In order to capture the psychological reception from the painted spaces, 31 pairs of bi-polar adjective phrases were selected carefully through the preliminary experiment. The images of the 15 paintings are printed at high resolution\(^2\) in the actual sizes and posted on the wall so that the

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\(^2\) HP DesignJet T790 ePrinter (max. Resolution: 2400 x 1200 dpi) was used.
center of each painting is at 1.5 meters from the floor. Uninformed of the titles of the paintings, the 50 students from the Department of Architecture (22 Males, 28 Females) were to stand at the distance twice as the diagonal dimension of each painting, and view each image (Fig. 2). They were to rate their impression between each set of bi-polar adjectives at 6 grades.

The average ratings of each pair of bi-polar adjective phrases and their standard deviation for each painting are calculated for the analysis. The landscape paintings generally received high grades of evaluation, and among them, most characteristic one was [SEI]. It was evaluated highest in 13 out of 31 phrases. [PAS] also received similar evaluations as [SEI]. Especially small standard deviations of ratings for both paintings indicate that all the viewers had similar impressions on them. Overall, the bi-polar adjectives whose average ratings were more than 4 or less than 3 were “Deep Space” (12 out of 15) as well as “Rural” and “Quiet” (11 out of 15). These results show that while many of the subject paintings depicts natural environments, they tend to evoke similar impressions to the viewers.

**Extraction of Representative Factors of Psychological Evaluation**

The factor analysis\(^3\) is performed using the ratings for 31 bi-polar adjectives on 15 paintings as variables in order to understand the structure of the psychological evaluation on spaces in two-dimensional representation (Tab. 2).

\(^3\) Statistical Software: SPSS (Principal Axis Factoring Method, Varimax Rotation).
Table 2. List of Psychological Factor Loadings

<table>
<thead>
<tr>
<th>Factor Name</th>
<th>Variables (+: Left Factor, -: Right Factor)</th>
<th>No.1</th>
<th>No.2</th>
<th>No.3</th>
<th>No.4</th>
<th>No.5</th>
<th>No.6</th>
<th>No.7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambience Factor</td>
<td>Comfortable - Uncomfortable</td>
<td>0.82</td>
<td>0.08</td>
<td>-0.11</td>
<td>0.12</td>
<td>0.17</td>
<td>0.04</td>
<td>-0.10</td>
</tr>
<tr>
<td></td>
<td>Beautiful - Ugly</td>
<td>0.78</td>
<td>0.17</td>
<td>0.10</td>
<td>0.02</td>
<td>0.23</td>
<td>0.03</td>
<td>-0.08</td>
</tr>
<tr>
<td></td>
<td>Cold - Warm</td>
<td>-0.76</td>
<td>0.17</td>
<td>0.03</td>
<td>-0.16</td>
<td>0.07</td>
<td>-1.01</td>
<td>-0.05</td>
</tr>
<tr>
<td></td>
<td>Dark - Bright</td>
<td>-0.76</td>
<td>0.21</td>
<td>0.05</td>
<td>0.01</td>
<td>0.12</td>
<td>0.03</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>Pure - Muddy</td>
<td>0.73</td>
<td>0.21</td>
<td>-0.02</td>
<td>0.05</td>
<td>0.26</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td>Stiff - Soft</td>
<td>-0.69</td>
<td>0.13</td>
<td>-0.03</td>
<td>-0.33</td>
<td>-0.06</td>
<td>-0.13</td>
<td>0.17</td>
</tr>
<tr>
<td></td>
<td>Enjoyable - Boring</td>
<td>0.68</td>
<td>-0.30</td>
<td>0.13</td>
<td>0.08</td>
<td>0.04</td>
<td>-0.09</td>
<td>-0.08</td>
</tr>
<tr>
<td></td>
<td>Closed - Open</td>
<td>-0.65</td>
<td>0.16</td>
<td>0.12</td>
<td>-0.14</td>
<td>-0.37</td>
<td>-0.01</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Dull - Atmospheric</td>
<td>-0.57</td>
<td>0.09</td>
<td>-0.15</td>
<td>-0.05</td>
<td>-0.08</td>
<td>-0.02</td>
<td>0.42</td>
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<tr>
<td></td>
<td>Colourful - Monotonous</td>
<td>0.55</td>
<td>-0.30</td>
<td>0.20</td>
<td>0.07</td>
<td>-0.22</td>
<td>0.05</td>
<td>-0.10</td>
</tr>
<tr>
<td></td>
<td>Disproportion - Harmonious</td>
<td>-0.54</td>
<td>-0.09</td>
<td>0.30</td>
<td>-0.11</td>
<td>-0.17</td>
<td>0.07</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td>Transparent - Opaque</td>
<td>0.51</td>
<td>0.23</td>
<td>0.01</td>
<td>0.03</td>
<td>0.20</td>
<td>0.10</td>
<td>-0.21</td>
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<tr>
<td>Dynamic</td>
<td>Quiet - Noisy</td>
<td>-0.07</td>
<td>0.78</td>
<td>0.01</td>
<td>0.09</td>
<td>0.15</td>
<td>0.08</td>
<td>-0.08</td>
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<tr>
<td></td>
<td>Restless - Calm</td>
<td>-0.26</td>
<td>-0.70</td>
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<td>-0.12</td>
<td>-0.09</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>Dynamic - Static</td>
<td>0.12</td>
<td>-0.66</td>
<td>-0.02</td>
<td>0.08</td>
<td>0.08</td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Eventful - Uneventful</td>
<td>0.25</td>
<td>-0.56</td>
<td>0.17</td>
<td>0.01</td>
<td>0.08</td>
<td>0.04</td>
<td>-0.12</td>
</tr>
<tr>
<td>Dramatic</td>
<td>Fantastic - Realistic</td>
<td>0.08</td>
<td>0.08</td>
<td>0.76</td>
<td>-0.04</td>
<td>-0.04</td>
<td>0.01</td>
<td>0.03</td>
</tr>
<tr>
<td></td>
<td>Ordinary - Dramatic</td>
<td>0.15</td>
<td>0.29</td>
<td>-0.62</td>
<td>0.06</td>
<td>0.11</td>
<td>0.17</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>Insipid - Symbolic</td>
<td>0.06</td>
<td>0.12</td>
<td>-0.39</td>
<td>0.09</td>
<td>0.22</td>
<td>0.39</td>
<td>0.20</td>
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<tr>
<td></td>
<td>Decorative - Plain</td>
<td>0.18</td>
<td>-0.30</td>
<td>0.33</td>
<td>-0.07</td>
<td>-0.23</td>
<td>0.08</td>
<td>-0.11</td>
</tr>
<tr>
<td>Rurality</td>
<td>Urban - Rural</td>
<td>-0.18</td>
<td>-0.20</td>
<td>-0.01</td>
<td>-0.65</td>
<td>-0.10</td>
<td>0.09</td>
<td>-0.06</td>
</tr>
<tr>
<td></td>
<td>Natural - Artificial</td>
<td>0.39</td>
<td>0.17</td>
<td>-0.10</td>
<td>0.50</td>
<td>0.34</td>
<td>0.05</td>
<td>-0.09</td>
</tr>
<tr>
<td></td>
<td>Rectilinear - Curvy</td>
<td>-0.16</td>
<td>0.16</td>
<td>-0.14</td>
<td>-0.44</td>
<td>-0.04</td>
<td>-0.22</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>Human Scale – Inhuman Scale</td>
<td>0.01</td>
<td>-0.03</td>
<td>-0.17</td>
<td>0.43</td>
<td>-0.09</td>
<td>0.04</td>
<td>-0.07</td>
</tr>
<tr>
<td></td>
<td>Old - New</td>
<td>-0.31</td>
<td>0.08</td>
<td>0.23</td>
<td>0.33</td>
<td>0.18</td>
<td>0.11</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>Being in Image – Distant from Image</td>
<td>0.16</td>
<td>-0.03</td>
<td>-0.20</td>
<td>0.30</td>
<td>0.03</td>
<td>-0.03</td>
<td>-0.22</td>
</tr>
<tr>
<td>Openness</td>
<td>Broad Space – Tight Space</td>
<td>0.50</td>
<td>-0.07</td>
<td>-0.13</td>
<td>0.15</td>
<td>0.55</td>
<td>0.08</td>
<td>-0.04</td>
</tr>
<tr>
<td></td>
<td>Deep Space – Shallow Space</td>
<td>0.16</td>
<td>0.07</td>
<td>-0.06</td>
<td>0.01</td>
<td>0.41</td>
<td>0.17</td>
<td>-0.06</td>
</tr>
<tr>
<td>Strength</td>
<td>Weak - Strong</td>
<td>0.02</td>
<td>0.30</td>
<td>-0.07</td>
<td>0.05</td>
<td>0.05</td>
<td>0.57</td>
<td>0.20</td>
</tr>
<tr>
<td></td>
<td>Symmetrical - Asymmetrical</td>
<td>-0.01</td>
<td>0.09</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.06</td>
<td>-0.34</td>
<td>0.12</td>
</tr>
<tr>
<td>Humidity</td>
<td>Humid Air - Dry Air</td>
<td>-0.22</td>
<td>-0.06</td>
<td>-0.19</td>
<td>-0.16</td>
<td>-0.06</td>
<td>-0.01</td>
<td>0.41</td>
</tr>
<tr>
<td></td>
<td>Eigenvalue</td>
<td>7.63</td>
<td>3.75</td>
<td>2.02</td>
<td>1.82</td>
<td>1.40</td>
<td>1.16</td>
<td>1.04</td>
</tr>
<tr>
<td></td>
<td>Contribution (%)</td>
<td>23.30</td>
<td>10.54</td>
<td>4.69</td>
<td>3.96</td>
<td>2.47</td>
<td>1.99</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Source: Kiwa Matsushita, Hiroshi Tsumita.
The factor loadings were calculated and 7 representative factors whose eigenvalues are above 1 were assessed. The first representative psychological factor consists of the evaluation scales, such as “Comfortable – Uncomfortable”, “Beautiful – Ugly”, and “Cold – Warm”. It can be defined as “Ambience Factor” since it represents the atmospheric characteristics of painted space. The second representative factor consists of the evaluation scales, such as “Quiet – Noisy”, “Restless – Calm”, and “Dynamic – Static”. This factor expresses a sense of movement in the space, so that it can be defined as “Dynamic Factor”. The third representative psychological factor includes the evaluation scales, such as “Fantastic – Realistic”, “Ordinary – Dramatic”. It can be defined as “Dramatic Factor” since it represents the dramatic quality of the painted space. The forth representative factor consists of the evaluation scale, “Urban – Rural” and “Natural – Artificial”. This factor represents the scale of rurality in the painted space, so that it is defined as “Rurality Factor”. The fifth representative factor consists of the evaluation scale, “Board Space – Tight Space” and “Deep Space – Shallow Space”. It expresses the extent of space, thus it can be defined as “Openness Factor”. The sixth representative factor consists of “Weak – Strong” and “Symmetrical – Asymmetrical”. It expresses the strength of space, so that it can be named “Strength Factor”. The seventh representative factor was “Moist Air– Dry Air” and it can be defined as “Moisture Factor” since it expresses the aerial dryness of the painted space. These seven psychological representative factors accumulate to the contribution of 48.477%. The following analysis uses the representative psychological evaluation scales, which are selected from these 7 representative factors (Shaded evaluation scales in Tab. 2).

Classification of Psychological Evaluation Characteristics

To categorize the distinctive types of the reception from the psychological evaluations and the composition of the corresponding paintings, the Cluster Analysis\(^4\) was performed by taking the average ratings of the 7 representative psychological scales for the paintings as the similarity and they were classified into 4 types (Fig. 3).

The average ratings of the representative psychological evaluation scales were plotted in radar charts according to the categories of the paintings to analyze the characteristics (Fig. 4).

The first group is “Serene Rural Type”, which was characterized by “Quiet”, “Ordinary”, “Rural”, and “Broad”. [PAS], [SEI], [HAA], [MAX], and [GLE] belong to this type. These paintings characteristically depict rural sceneries with large amount of sky and the background in far distance, but the presence of specific human or building is not stressed. Even when humans are depicted, they do not give strong impressions, since they are painted small or their faces are turned to back, so their expressions are unreadable.

\(^4\) Statistical Software: SPSS (Furthest Neighbor Method).
Also, the orientation of 4 out of 5 paintings in this type are landscape, and 3 out of 5 paintings have rivers placed horizontally, which make the stable compositions. These characteristics presumably lead to “Quiet” and “Ordinary” impressions. [PAS] and [SEI] shared especially similar evaluations and even though they are painted in different age and styles, their compositions are remarkably alike. They both have a river flowing in the middle-ground as well as the large tree on right or left in the foreground, which express the expanse of space horizontally and vertically. The viewers’ eyes start from the human figures at foot of trees in the foreground and are lead deep into the space by the buildings in the background. These compositions supposedly contribute to the sense of “Broadness” (Fig. 5).

The second is “Bustling Rural Type”, which shows similar tendencies in the some evaluation scales, such as “Rural” and “Broad”, but also rated high on “Noisy” and “Dramatic” scales. This type includes [BLB], [JOP], [STW], and [GRO]. The characteristics of the painted spaces in this type is, on one hand, similar to “Serene Rural Type”. They both depict rural scenery with many trees. The major difference is that “Bustling Rural Type” have several human figures in the foreground. The scale of “Noisy” impression was proportion to the level

Fig. 3. The Classification of the Paintings based on the Cluster Analysis
Source: Kiwa Matsushita, Hiroshi Tsumita.

Fig. 4. The Radar Charts of the 4 Categories of Paintings
Source: Kiwa Matsushita, Hiroshi Tsumita.
of human movements, while the rating of “Dramatic” was high, regardless of the level of movements. 3 out of 4 paintings in this category had considerably noticeable architecture in the middle-ground. These architectural elements presumably act as a backdrop, partitioning off the human figures in the foreground from the large sceneries in the background, in order to focus the viewers’ eyes to the acts of human figures (Fig. 6).

![Fig. 5. Composition Examples of “Serene Rural Type”](image)

Source: Kiwa Matsushita, Hiroshi Tsumita.

![Fig. 6. Composition Examples of “Bustling Rural Type”](image)

Source: Kiwa Matsushita, Hiroshi Tsumita.

The paintings in the third group also had high rating in “Rural”, but also the evaluation scales, such as “Cold” and “Tight” were particularly rated high. [UTR], [MEZ], [MMS], [AGO] and [TEM] were categorized in this group, which can be defined as “Anxious Rural Type” from the characteristics of the painted spaces. 4 out of 5 paintings in this group are portrait orientation and have dark colour tone. The impression of the buildings are relatively strong, but their appearances as well as the distance from the other elements are distorted, creating the sense of tension and anxiety (Fig. 7).

The last type is characterized by the evaluation scales, “Noisy”, “Urban” and “Dry”, so it is defined as “Bustling Urban Type”. Only [PTF] were designated to this type. It depicts the hustle-bustle traffic scene in the central urban area with countless number of people, so it gives noisy and urban impression. The composition
is birds-eye-view, so no sky is painted. The trees without a leaf suggest that the scene is in dry winter, giving the impression of “Dry Air”.

**Conclusion**

The psychological experiment based on the SD method was conducted using 15 Western paintings between the 16th and 20th centuries in order to survey the psychological evaluation of the two-dimensional spaces. According to the propensities of the evaluations, 7 representative factors are selected as well as the representative evaluation scales. The subject paintings were categorized into 4 types through the Cluster analysis using the representative evaluation scales as similarities and the compositions of the paintings are compared in each categories.

These analyses revealed a part of the characteristics of the perception on the architecture and spaces in the form of Western paintings. Regardless of the time period or style, the elements and their compositions have influences on the viewers’ impression and psychological evaluation of the paintings. Especially in the rural scenery, human and architectural elements are considered to be the factors to evoke dramatic and/or dynamic impressions.
Based on the result of this research, by increasing the number of the subject paintings and more variation in ways of depicting buildings, the next experiment will analyze more various architectural representations, and clarify the relationship between the psychological evaluations of two-dimensional spaces, and the their compositions and the painted elements.