Comparative Evaluation of Unit Layout Alternatives in Plan-Extension Remodeling of Domestic Korean Apartments

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Abstract
It has been over 30 years since apartments began to be built on a nation-wide scale, to become the most common housing type in Korea. Now that some time has passed, the earlier apartments are deteriorating in physical quality and have become outdated in regards to the lifestyles of contemporary residents. Up to the most recent years, such aged apartments would be demolished and rebuilt with increased density. However, for sustainability reasons, many argue that "remodeling," where the main structure of the apartments are retained and only internal configurations are modified, should be preferred over the current "demolish-and-rebuild" patterns. In order to adopt remodeling, it is critical that architectural strategies to overcome the physical constraints presented from retaining the existing structure are developed. In this study, the author was able to witness a pair of unit layout plans where one followed the traditional planning conventions and the other was more experimental in overcoming the constraints. Through various means such as POE, Space Syntax, and "Perceptive Spaciousness Model," a model the author developed based on Michael Benedikt's Isovist model, the experimental alternative proved to be preferable for remodeling.

Keywords: remodeling; apartments; POE; space syntax; perceptive spaciousness

1. Introduction
The housing stock in Korea is quite unique, being dominated by apartments, a housing type disregarded in most cultures. Following the Korean War, the nation experienced unprecedentedly rapid industrialization and urbanization, thus facing an explosive increase in housing demand around metropolitan areas. To meet such demands, apartments were adopted in massive quantities. Since then, apartments have become the symbol of economic prosperity and to own an apartment has become the dream of many households. In 2010, among 13,883,571 housing units, 8,185,063 were apartments while 53.8 percent of the national population lived in apartments.

It is now more than 30 years since these apartments were built nation-wide. Now that quite some time has passed, the earlier apartments are deteriorating in physical quality, resulting in increased living costs. More importantly, the lifestyles of the general population have changed, while the apartments have become outdated and need renewal. For such renewals, the method of "demolish-and-rebuild" has been adopted. However, such patterns are criticized for sustainability reasons. In general, the structural skeleton of an apartment can last for more than 100 years, and those being discarded in less than half of their lifespan ought to be seen as a waste of resources. As is the case of most common goods, recycling is the best measure in achieving sustainability and apartments are no different; they must be used to their full time capacities. This is where the concept of "remodeling" gains significance. With the building structure being retained, service facilities can be replaced and the internal configurations can be modified to fit with the lifestyles of contemporary residents.

However, modifying internal configurations while retaining the existing structure can be quite a challenge in adopting "remodeling." Developing architectural strategies that overcome such physical constraints are the key factor and examinations of their effectiveness are crucial. In this study, the author will comparatively evaluate a pair of remodeled unit layouts of the same apartment where one follows the traditional planning conventions and the other is more experimental in overcoming the constraints. The evaluation will focus on the livability and spatial quality of the unit layout alternatives.

2. Major Concepts & Methodology
2.1 Korean Apartments
"Apartments," in western culture, are synonymous with "multi-family housings;" they focus on the qualities that can be achieved by living nearby other...
households. In Korea however, apartments were adopted for their mass-productivity; they are mere repetitions of unit plans that lack gestures of communal qualities. While many criticize the aesthetic quality of Korean apartments, other scholars argue that these apartments symbolize the rapid industrialization and economic prosperity both the country and the individual achieved. (Jeon (2009) & Gelezeau (2007)) Such arguments can be justified by the fact that apartment owners tend to move into larger units as they gain economic status and make a display of (or "show off") their achievements.

Chronologically, the first mass-produced apartments were built from the mid-60s to the mid-70s, most projects of which were led by the public sector. The next decade (mid-70s to mid-80s) was a period of apartment projects built by the private sector; thus the housing type being diffused throughout the housing market. In the late-80s to the mid-90s, newly built satellite cities around the Seoul metropolitan area were filled with apartments as the national government set out visions to supply more than 2 million housing units in only 5 years. (Choi, 1996)

In this study, the mass-productivity of apartments is seen as an opportunity for "mass-remodeling." That is, if a remodeling method is developed, it can be applied to the entire apartment building, thus achieving sustainability on a larger scale. More noticeable is that Korean apartments are repetitions of units not only within an apartment building but among other apartment buildings as well. It has been reported that more than half of the domestic apartment stock can be categorized into just four unit layout types. (Ministry of Land, Transport, and Maritime Affairs, 2006)

Another study reports that the unit layout plans used in the late-80s for the "2 million housing vision" have become the standard unit layouts and are still being used in the 21st century. Fig.1. compares two unit plans from 1985 (left) and 2000 (right). Not only are they the typical layouts from their respective eras, they are almost identical; consisting of bedroom, living room and bedroom in the southern bays, and bedroom, kitchen and bedroom in the northern bays, despite the difference in their construction dates. (Choi et al., 2004). This opens the possibility that a standardized remodeling strategy can be achieved and applied to a significant portion of the national apartment stock.

2.2 Remodeling & Plan-Extension Remodeling

The term "remodeling" can be misleading due to the wide range of building activities it implies. It can refer to mere interior design renewals such as reinstalling floor tiles and wallpapers, but also can refer to extending the existing building to add new functional spaces. Note that in this study, the term is used in opposition to "rebuilding."

At the beginning of the 21st century, a new phenomenon known as "rebuilding" arose. That is, apartments from decades ago were demolished and replaced with new apartments. The main purpose of "rebuilding" is to "mass-replace" the deteriorating apartments and provide apartments that are up-to-date with the current lifestyles. For example, the early apartment units featured a small "maid's room," a room that is no longer needed and removed in the new apartment units. For "rebuilding" projects, it is generally assumed that the ownership does not change; owners collectively demolish the old units and build new ones. This seemingly infeasible process is made feasible by increasing the development density, i.e. floor-area ratio of the apartment site. However, with the rise of awareness concerning sustainability, "rebuilding" projects are being criticized for the massive amount of waste produced and resources wasted by demolishing building skeletons that have decades of lifespan remaining. To restrain such "rebuilding" projects, apartments cannot be "rebuilt" for at least 20 years from the date of their completion.

"Remodeling," on the other hand, attempts to "mass-repair" deteriorating apartments and "update" the internal layouts, without the complete demolition of the building skeleton. In order to adopt remodeling over rebuilding, it too needs to be given incentives. "Remodeling" projects can begin after just 15 years from completion. To further promote remodeling, the national government has recently (April, 2013) allowed vertical extension (increasing the number of floors of an apartment building) despite the negative effects this can have on solar rights. Most importantly, extensions to the existing building are allowed, thus increasing the size of the units by up to 30 percent. Therefore, in this paper, the term "remodeling" refers to building activities for renewal on a collective scale, and most importantly assumes plan-extension.

2.3 Constraints of Plan-Extension Remodeling

Koreans strongly prefer south-facing units and highly regard cross ventilation and natural lighting. This limits the depth of the unit plans as excessive depth can decrease the quality of natural ventilation and lighting. Fig.2. demonstrates how units are similar in depth but different in width according to their overall sizes.

However, the orientation of plan-extension remodeling is limited to increasing the depth of the unit

Fig.1. Standardized Unit Plans (Choi et al., 2004)
(Typical plans of 1985 (left) and 2000 (right))
since extension in the purlin-direction is physically impossible due to the adjacent units. Not only does this lack environmental quality, the sizes of the subspaces remain practically unchanged with the additional floor area being left without particular use. Considering how an apartment unit is symbolic of one's economic status, the unchanged sizes of subspaces can lead to discontent with the remodeled unit. Specifically, the living room, which according to Lee et al. (2005) is planned proportionate to the size of the unit, can decrease the perceived size of the unit. Therefore, remodeling plans should focus on these constraints and explore ways to utilize the additional floor area and either physically or perceptionally increase the sizes of major subspaces.

2.4 Subject of Comparative Evaluation

One apartment complex, which will be referred to as the "S apartment," that consists of three buildings (thus three unit types) and was collectively remodeled was chosen for comparative evaluation of unit layout alternatives for plan-extension remodeling. Among the three unit types, the largest unit type (pre-remodeling floor area 126.68 sq.m, 72 units) was remodeled with two different layout alternatives shown in Fig.5. and Table 1. It is worth noting that the original plan follows the standardized unit layout discussed in Fig.1. If one alternative turns out to be preferable over the other, we can cautiously say that it is the "right way" to plan apartment-remodeling projects.

Remodeling alternative B (48 units) follows the layout conventions used in the original plan. That is, the three southern bays consist of bedroom, living room, and master bedroom while the three northern bays consist of bedroom, dining/kitchen, and bedroom. Although all subspaces were enlarged, a significant amount of the additional floor area has been allocated to the dining area, which could actually be included in the kitchen area. The result resembles what was previously described with Fig.3. That is, the size of the living room is increased by the minimum.

Remodeling alternative A (24 units) can be understood as an attempt to overcome the physical constraints by simply switching the kitchen in the north with the bedroom in the south. The result of this manipulation is that the bedrooms form a cluster around a transitional zone that will be referred to as "family room." By providing an additional layer of space between the private and public zones, the family room can provide better privacy to the individuals. The dining area in alternative B, which corresponds to the family room, however, lacks this function as it is located between two public zones. How these differences affect the livability of the units will be discussed in section 3 of this paper.

The visual permeability between the living room and dining/kitchen in alternative A is also a key aspect of the layout. By allowing visual permeability in more directions, the perceived spatial quality can differ. This will be explored extensively in section 4 of this paper.

The significance of the S apartment is that it provides an almost laboratory-like condition to evaluate the effectiveness of an experimental architectural strategy. Apart from the layouts, almost all the other factors, such as location, construction quality, sizes of subspaces etc. are controlled.

2.5 Methodology

(1) Post-Occupancy Evaluation

Section 3 of this paper will comparatively evaluate the livability of remodeling alternatives A and B. While the term "livability" can have various implications, the best way to measure it would be to survey the residents. The survey was open to only the households that resided both pre-remodeling and post-remodeling, for they would clearly understand the differences brought through the renewal. For alternative A, 16 returning households participated in the survey, while only 8 returning households participated for alternative B. Though there may be more qualifying households that refused to participate, the fact that only 8 (out of 48) households were returning to live in alternative B already hints that alternative B is less preferable.

The survey consists of questions asking the participants to express, on a 5-point scale, how satisfied they were with each subspace in their respective units. The questionnaires were distributed and returned by mail. The responses were statistically analyzed by T-Test where subspaces with statistically significant difference in mean satisfactory scores are of interest.
While the Post-Occupancy Evaluation survey can reveal the preference (and thus livability) between remodeling alternatives A and B, it cannot verify whether it was the architectural layout that determined the preference patterns.

It was previously mentioned that remodeling alternative A had an additional layer of space between the private bedrooms and public living room and dining/kitchen, thus providing increased privacy to the individuals. Such descriptions of public-private can be quantified through Space Syntax, developed by Hillier & Hanson (1984). It analyzes the connections between spaces and determines which spaces have a higher level of centrality, are integrated with other spaces, and thus, are public, while other spaces have less centrality, are segregated from other spaces, and thus, are private.

To take Fig.6, for example, an apartment plan is conceptually reproduced into what is called a convex map. Each subspace becomes a node while links are created between nodes when their respective spaces are directly accessible with each other. Then, the mean depth of each node is calculated, where directly linked nodes are considered to exist at 1 depth and nodes directly linked to nodes at 1 depth are considered to exist at 2 depths, and so on. For example, node 5 (corridor) has six nodes (nodes 1, 2, 3, 4, 6, 8) at 1 depth and 3 nodes (nodes 7, 9, 10) at 2 depths. Thus the mean depth for node 5 is: \( [(6 \times 1) + (3 \times 2)] / 10 = 1.2 \), meaning that from node 5, other spaces can be accessed by moving 1.2 depths. Reiterating the procedure for node 10 (toilet), its mean depth is 2.4, meaning that it takes twice as much effort to access other spaces compared to node 5. In this case, node 5 has relatively greater centrality, is more integrated, and more public compared to node 10.

In this paper, the integration index will be used to describe the publicness-privateness of subspaces. Though the mean depth index is not identical with integration, the latter is based on the former and is inversely proportional within a setting and is calculated as follows:

\[ I = D_k(k - 2)/2(MD - 1) \]
In section 4 of this paper, remodeling alternatives A and B will be evaluated by their spatial qualities; that is, how the perceived size of the units and subspaces can differ according to the layouts adopted. Such comparative analysis is unprecedented but has the theoretical background to be experimented. Benedikt (1979) has proposed the Isovist model which is simply the space that can be seen from a fixed location within an architectural setting. Fig. 7. is an example of an Isovist where the shaded area is the Isovist field for the generating location. From this Isovist field, several mathematical indexes can be extracted. The simplest of which is the Area of Isovist (A) which is the geometric area of the Isovist field. Other indexes regarding the perimeters and radials can also be extracted.

Stamps III (2005) has illustrated the indexes which are shown in Table 2. Benedikt himself has experimented on using these indexes to quantify perceived space, but has limitations in that the settings were too arbitrary. (Benedikt, 1985) His experiment can also be criticized in that the dependent variable (perceptive spaciousness) was merely a binary comparison of which one setting seemed larger than the other, without comparing the extent to which one space was perceived as larger than the other. In this paper, the author will experiment on quantifying perceptive spaciousness and determine which Isovist indexes can best describe the perceived space through statistical regression.

Table 3. T-Test of Satisfactory Score of Subspaces

<table>
<thead>
<tr>
<th>Subspace</th>
<th>Alt</th>
<th>Freq.</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>T</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living</td>
<td>A</td>
<td>15</td>
<td>4.00</td>
<td>.756</td>
<td>.849</td>
<td>.405</td>
</tr>
<tr>
<td>Room</td>
<td>B</td>
<td>8</td>
<td>3.75</td>
<td>.463</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Master Bedroom</td>
<td>A</td>
<td>15</td>
<td>4.07</td>
<td>.704</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedroom</td>
<td>B</td>
<td>8</td>
<td>3.88</td>
<td>.641</td>
<td>.641</td>
<td>.529</td>
</tr>
<tr>
<td>Other</td>
<td>A</td>
<td>15</td>
<td>4.07</td>
<td>.458</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bedooms</td>
<td>B</td>
<td>8</td>
<td>3.63</td>
<td>.518</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitchen</td>
<td>A</td>
<td>16</td>
<td>3.88</td>
<td>.957</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>8</td>
<td>3.13</td>
<td>.354</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dining Room</td>
<td>A</td>
<td>15</td>
<td>3.73</td>
<td>.884</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Room</td>
<td>B</td>
<td>8</td>
<td>3.13</td>
<td>.354</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toilet</td>
<td>A</td>
<td>15</td>
<td>3.53</td>
<td>1.060</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>8</td>
<td>3.13</td>
<td>.641</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ensuite</td>
<td>A</td>
<td>15</td>
<td>3.73</td>
<td>1.033</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>8</td>
<td>3.25</td>
<td>.707</td>
<td>1.178</td>
<td>.252</td>
</tr>
<tr>
<td>Entrance</td>
<td>A</td>
<td>15</td>
<td>3.73</td>
<td>.799</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>8</td>
<td>4.00</td>
<td>.535</td>
<td>-1.844</td>
<td>.408</td>
</tr>
<tr>
<td>Southern</td>
<td>A</td>
<td>15</td>
<td>3.93</td>
<td>.884</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balcony</td>
<td>B</td>
<td>8</td>
<td>3.63</td>
<td>.744</td>
<td>.839</td>
<td>.411</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>15</td>
<td>3.93</td>
<td>.799</td>
<td>2.462</td>
<td>.023*</td>
</tr>
</tbody>
</table>

3.2 Space Syntax

Table 4. numerically compares the integration of subspaces. The integration values show that integrations of bedrooms, WC, and northern balcony are lower in alternative A compared to alternative B.
What is of great interest is that the subspaces with differing integration values coincide with the subspaces that showed statistically significant difference in satisfactory scores from Table 3.

Also noticeable is that in alternative A, the public subspaces such as living room and dining/kitchen are even more public (higher integration) while private subspaces such as bedrooms are even more private (lower integration) compared to alternative B. Such "polarization" seems to fit with contemporary values where socialization and personal privacy are respected. Therefore, it can be concluded that the public-private relationship of spaces is the dominating factor for satisfactory living, and that remodeling alternative A has a great advantage in this respect.

4. Perceptive Spaciousness Analysis

Benedikt's Isovist model has great potential to be used to measure the spatial quality of architectural spaces in terms of how the spaces can "seem" or "feel" bigger or smaller by the geometry of their respective Isovist fields, even if the physical size of the spaces are the same. This is the situation with the two remodeling alternatives for they are nearly identical in total floor area but differ in the geometry of their Isovist fields. However, Benedikt was uncertain on how to weight the Isovist indexes to construct a numerical model that can measure perceptive spaciousness due to the insufficient methods in quantifying perceptive spaciousness.

4.1 Quantifying Perceptive Spaciousness

The key to quantifying perceptive spaciousness is that the quantification need not be in the form of absolute dimensions that one feels a particular space is (for example, "a room that seems to be 20 sq.m") Such quantifications rely heavily on the individual's skills in estimating dimensions. Perceptive spaciousness therefore, can only be relative comparisons of how two spaces are perceived. For example, one can describe a space as "this space seems much bigger than that space" or "this space looks a little smaller than that space" Notice the emphasis on the words describing by how much one space dominates the other. These are the words neglected by Benedikt's original experiment, and should be considered in quantifying perceptive spaciousness.

The Analytic Hierarchy Process (AHP) is a technique based on mathematics and psychology that can rank a certain aspect of entries based on their pairwise comparison. For this study, pairwise comparisons of the perceptive spaciousness of different spaces can be processed to quantify the relative perceptions. The author selected 8 apartment plans and reproduced their internal spaces through 3D modeling as shown in Fig.9. The viewpoint was fixed at the point of maximum Area of Isovist (A), while the direction of view could be rotated freely, thus providing a panoramic view of the setting. By examining a pair of these images, one can determine which of the two seemed more spacious and by how much. Thirty students enrolled in an introductory course volunteered to participate in this comparison, with each participant comparing 28 pairs of images. Comparisons were recorded on a 7-point scale answer sheet where one end of the scale meant a space seemed much bigger compared to the other, and at the other end of the scale vice-versa. In reality, the 8 apartment plans were identical in size, but had different Isovist field geometries.

Table 5. shows the final results of the relatively quantified perceptive spaciousness for the 8 different plans, where plan 5, with the highest index, is perceived as the most spacious and plan 2 the least spacious.

4.2 Statistical Regression of Isovist Indexes on Perceptive Spaciousness

Now that the perceptive spaciousness of the plans
have been quantified, statistical regression between the Isovist indexes (independent variable) of the plans and their respective perceptive spaciousness (dependent variable) can be conducted to determine the weighting of each independent variable. The Isovist indexes were extracted from Isovist fields generated from the point of maximum Area of Isovist (A) within each plan, hence the viewpoints of the aforementioned 3D reproductions. The indexes are as shown in Table 6.

Table 6. Isovist Indexes of Regression Cases

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>.120</td>
<td>.024</td>
<td>.0</td>
<td>-4.919</td>
</tr>
<tr>
<td>A</td>
<td>3.382E-009</td>
<td>.000</td>
<td>1.059</td>
<td>10.492</td>
</tr>
<tr>
<td>M3</td>
<td>.039</td>
<td>.010</td>
<td>.388</td>
<td>3.840</td>
</tr>
</tbody>
</table>

Fig. 10. and Table 8. show the Isovist indexes of the two remodeling alternatives from the S apartment, extracted from Isovist fields generated from the center of the living room. As predicted, the Area of Isovist (A) is quite similar to M3 showing significant difference. Applying these variables to the regression model (unstandardized coefficients), perceptive spaciousness of the alternatives can be predicted, with alternative A being preferable.

Table 8. Isovist Indexes of Remodeling Alternatives

<table>
<thead>
<tr>
<th>Alt</th>
<th>A</th>
<th>P</th>
<th>Q</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>56577694</td>
<td>34454.531</td>
<td>14747.244</td>
</tr>
<tr>
<td>B</td>
<td>53470959</td>
<td>36380.308</td>
<td>8450.507</td>
</tr>
</tbody>
</table>

\[ PS_A = -0.120 + 56,577,694 \times 3.382 \times 10^{-9} + 2.348 \times 0.039 = 0.163 \]

\[ PS_B = -0.120 + 53,470,959 \times 3.382 \times 10^{-9} + 1.349 \times 0.039 = 0.113 \]

5. Conclusion

At the beginning, the author discussed the unique cultural meaning of apartments in Korea, and how they have potential advantages in achieving sustainability through remodeling. In the local context, remodeling must assume plan-extension in order to be adopted. With physical constraints, however, the additional floor areas were more likely to be less perceived. This is where a new layout convention had to be explored and its efficiency verified. The new layout convention (frequently referred to in this paper as "remodeling alternative A") was comparatively evaluated with an alternative that followed the traditional layout convention ("remodeling alternative B"), by various methods such as Post-Occupancy Evaluation, Space Syntax, and Perceptive Spaciousness Analysis. While the first two methods focused on less-physical aspects, such as the public-private relationship of apartment layouts, the third method intensively analyzed the physical aspects or apartment layouts and how they tend to be perceived. This breakthrough was achieved by combining the Isovist model with Analytic Hierarchy Process (AHP).

All three evaluation methods concluded that remodeling alternative A would be preferable over alternative B. Thus, we can predict that the new layout convention will increasingly appear in the domestic housing market while the adoption of remodeling over demolishing-and-rebuilding relies heavily on the
congruence between the new layout convention and contemporary lifestyles.

However, this study has its limitations because it was solely focused on the unit plan layouts of remodeled apartments. At the site planning scale, the plan-extension increases the depth of the buildings thus reducing the external area of the site. Korean apartments are frequently criticized for lacking communal life, and such changes will only add to these problems. Furthermore, negative impacts such as reduced car-parking capacity and/or less green area can be expected. Reduced car-parking capacity can be a significant tradeoff as it can cause inconvenience. To address this issue, most apartment remodeling projects include the installation of underground parking, thus increasing costs and reducing feasibility. Less green area can affect the site's long-term microclimate and neutralize the sustainability achieved through remodeling. These issues must be considered comprehensively to confirm that remodeling is really the more sustainable way over rebuilding. It is then that remodeling projects should be initiated and the unit plans designed.

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