The Duality of Visibility: Does Visibility Increase or Decrease the Fear of Crime in Schools' Exterior Environments?

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Abstract

Visibility is an important factor that affects fear of crime in environments. This study suggests empirical evidence of the relationship between visibility and fear of crime in environments using an automated quantitative analysis method. Spots where children felt fear in exterior areas of elementary schools were aggregated, and their characteristics were analyzed with two visibility dimensions of visual connectivity with no visible distance restrictions and with visible distances restricted. In general, locations with lower levels of visibility reported higher levels of fear of crime. However, where there was very high visibility, fear of crime also increased. In other words, visibility has a dual nature, both increasing and decreasing fear of crime in environments. In addition, the visible distance was a significant element that affects fear of crime. With the assistance of methods and results of this study, designers can plan safer environments and improve existing environments by considering visibility in a systematic and significant manner.

Keywords: visibility; fear of crime; elementary school; space syntax; GIS (geographic information system)

1. Introduction

According to a survey of the Seoul metropolitan government (2010), Seoul citizens thought that the first priority of an education policy was 'school safety' (31.8%). However, schools have not received much scholarly attention concerning their relationship to crime (Roman, 2002). In addition, previous study (Salmon et al., 1998) suggests that children who are victims of criminal behavior tend to be in their earlier school years and children who experienced criminal behavior feel high anxiety and depression.

Although visibility is considered to be an important factor that affects fear of crime in environmental criminology (Andrews and Gatersleben, 2010, Fisher and Nasar, 1992, Loewen et al., 1993, Nasar and Fisher, 1993, Wang and Taylor, 2006), previous studies used few quantitative analysis techniques with automated computer routines to analyze visibility. Furthermore, they used visibility as one element that causes fear of crime instead of analyzing visibility only in more depth.

Therefore, a more in-depth study with respect to criminal behavior and visibility in elementary school areas would be valuable in environmental criminology. To be specific, this paper seeks the effects of visibility on fear of crime in elementary school environments.

In defining the scope of this research, there are several aspects to be considered. To begin with, the exterior areas of elementary schools were investigated because, exterior areas are different from interior or urban areas in terms of morphology, scale, and interpretation of visibility (Turner, 2003). Furthermore, school exterior areas show variable visibility, ranging from very high (e.g., playgrounds) to very low (e.g., the rear of buildings).

In addition, fear of crime is considered in its cognitive and emotional dimensions (Ferraro and Grange, 1987). As minor instances of victimization are common in schools (Garofalo et al., 1987), the scope of crime was extended to school violence. Therefore, crimes included violent crimes (assault, robbery, threats), property crimes (theft, fraud, pick-pocketing), peer violence (bullying, emotional bullying, gang assault), and sexual incidents (attempted and/or completed rape, sexual harassment, sexual molestation) following Hong (2008).

Furthermore, to find the spots where fear of crime was actually felt at the children's level, the survey was completed by students in an elementary school and excluded their teachers or other school officials. The surveys were anonymously completed by children aged
12 (fifth-graders) to 13 (sixth-graders), who experience considerable amounts of criminal behavior (Salmon et al., 1998) and who were capable of answering the questions in such a survey.

2. Literature Review

2.1 Fear of Crime in Environments

Previous studies have supported that cognitive (such as risk perception) and emotional (such as feeling afraid) dimensions of fear of crime need to be distinguished from one another (Ferraro and Grange, 1987, Rountree, 1998). Generally, information about fear of crime from previous studies (DuBow et al., 1979, Gray et al., 2008, Miceli et al., 2004) can be summarized as follows: (a) fear of crime is related to the environment; (b) fear of crime is more common than crime itself; (c) fear of crime is related to sociodemographic variables.

Furthermore, a lot of previous studies have mentioned a relationship between criminal behavior and environmental design (Brown et al., 2003, Jacobs, 1961, Jeffery, 1971, Taylor et al., 1984). Among environmental factors, visibility which was referred to as 'prospect' or 'surveillance' in earlier work was negatively related to criminal behavior. According to the theory of Fisher and Nasar (1992), fear of crime was low with high prospect levels. In addition, according to the theory of 'crime prevention through environmental design' (CPTED), natural surveillance is considered to reduce criminal behavior (Jacobs, 1961, Newman, 1972). Furthermore, several studies (Bennett and Wright, 1984, Fujii et al., 2013, MacDonald and Gifford, 1989, Pease, 1991) discussed the relationship between natural surveillance and criminal behavior.

In environmental criminology, studies assert that there are spaces in which concentrations of crime arise within a limited area (Block and Block, 1995, Sherman, 1995, Weisburd and Green, 1995). 'Hot spots' are the areas where these criminal behaviors commonly take place. Therefore, through the analyses of hot spots, the characteristics of the criminals, victims, and environments which increase the number of crimes could be identified (Maltz et al., 1991). Many previous studies (An and Yoshida, 2011, An and Yoshida, 2013, Takizawa et al., 2010) investigated hot spots through GIS (geographic information system), and among the statistical methods that can be used to identify hot spots, one of the most common is the density of crime incidents, which is continuous over an area, being higher in some parts and lower in others.

2.2 Visibility in Spaces

The isovist concept was suggested to develop the quantitative visibility analysis method. Tandy (1967) presented the first isovist concept in the area of spatial analysis, and Benedikt (1979) utilized it for quantitative descriptions of spaces with a set of analytic measurements (Turner et al., 2001). Benedikt (1979) proposes an isovist as "the set of all points visible from a given vantage point in space and with respect to an environment" (page 47). In addition, he suggested the concept of the 'isovist field', which is the resulting map of the contours of equal visual areas, suggesting that it may be useful in the study of the relationship between humans and environments.

Several methods — e.g., visibility graph analysis (VGA) (Turner et al., 2001) or visual dynamics analysis (VDA) (Lee and Lee, 2014) — can be used to calculate visibility relationships automatically. In this study, VGA was chosen as the method for the authors' analysis. It presents a grid over the spaces to be analyzed and investigates the visibility relationships of every point in the grid to every other point. The theory of isovist and space syntax (Hillier and Hanson, 1984) — a theory often used in previous studies (Choi et al., 2013, Kishimoto and Taguchi, 2014) to validate the relationships among spaces — was combined with VGA, and one important result of the combination was 'connectivity.' Connectivity in VGA is "how many locations each node can see" (Turner, 2001), page 10; it is the number of grids that are visible from a point, and it is related to the primary isovist concept.

Although some studies (Lee et al., 2013) have taken visual distance into consideration, few have clearly defined visible distances (Desyulas et al., 2003). In an earlier theory of environmental planning, Spreiregen (1965) noted human vision based on the following (page 71): (1) from 3 to 10 feet is in a "close relationship to us," (2) up to 40 feet "we can distinguish facial expression," (3) up to 80 feet "we can recognize a friend's face," (4) up to 450 feet "we can discern body gesture," and (5) 4,000 feet is the "maximum distance for seeing people." Desyulas et al. (2003) and Piao et al. (2012) used a distance of 100m as their restriction of the visible distance in criminal studies.

3. Methodology

3.1 Subjects

To select the elementary schools for the study, certain factors concerning school violence (Ministry of Education, 2012) — the number of students who were victims of crime and who recognized bully peers — were reviewed. Among 25 districts in Seoul, the most suitable district was the Songpa district. There were 1,114 students who were victims of crime (M. of the 25 districts = 553.40, S.D = 214.404) and 1,586 students who recognized bully peers (M. of the 25 districts = 785.64, S.D = 334.166). Among 37 schools in the Songpa district, to select the schools for the survey, the outlines of the school buildings which would define the shape of exterior areas were considered. As previous studies (Batty, 2001, Turner et al., 2001) mentioned that the VGA results are related to the morphologies of spaces, schools of various outlines were selected. Table 1 shows the various forms of the exterior spaces of selected schools and summarizes the features of the schools. In this study, 501 surveys in total were...
Table 1. Major Features of the Selected Schools

<table>
<thead>
<tr>
<th>School name</th>
<th>Plan (not to scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Building form</td>
<td>'sword' form</td>
</tr>
<tr>
<td>Area of the site (m²)</td>
<td>8,000</td>
</tr>
<tr>
<td>Building to land ratio (%)</td>
<td>22.36</td>
</tr>
</tbody>
</table>

Table 2. General Features of the Participants

<table>
<thead>
<tr>
<th>Fifth-graders (12 y)</th>
<th>Sixth-graders (13 y)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>130 (31.1%)</td>
<td>71 (17.0%)</td>
</tr>
<tr>
<td>Females</td>
<td>151 (36.1%)</td>
<td>66 (15.8%)</td>
</tr>
<tr>
<td>Total</td>
<td>281 (67.2%)</td>
<td>137 (32.8%)</td>
</tr>
</tbody>
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distributed, and among them 418 which were faithfully answered were analyzed. Table 2. presents the features of the participants.

3.2 Spots for Fear of Crime

As it was occasionally difficult for the elementary school students to respond to the complex questions, an aerial photograph of their own school exterior areas, and a visual analogue scale (VAS) were provided in the survey. VAS is used as a measuring tool for phenomena in fields where it is difficult to objectively measure (such as feeling or pain) (Cox and Davison, 2005), and previous studies (Arneill and Devlin, 2002, Devlin, 2008) have used the VAS to analyze feelings associated with environments. Fig.1. shows an example of part of a student's survey answer.

A pilot study was performed on a sample of students. To increase the reliability of the survey, the authors provided a survey scenario. The procedure of surveys was as follows: 1) for 15 minutes, the survey researchers explained the definition and scope of crime. As studies indicate that severe crimes are relatively rare whereas minor ones are common in schools, the range of crime was extended to school violence and the students were told that even minor issues could be critical information. 2) Students marked spots where they felt fear of crime on their aerial photograph of their own school exterior areas. The number of spots was limited to three due to space limitations. 3) To define the degree of fear of crime, a 10-cm VAS was presented. Students were asked how fearful they felt at the spots, and marked an "X" on a 10-cm line to denote the degree of fear, with 0 cm being the least fearful and 10 cm being the most fearful. 4) Students wrote the reason for fear of crime at each criminal spot in an open-ended answer. They were asked to make their reasons as specific as possible.

In the 418 surveys, a total of 858 spots for fear of crime were noted. All of the information was input into the ArcGIS program for analysis. Through ArcGIS, the density and degree of fear of crime results were visualized, after which 'hot spots' for fear of crime became noticeable. To investigate the effects of visibility on fear of crime, this study analyzed fear of crime in two ways: the density (frequency per grid) of spots for fear of crime (DS), and the sum of the degree of fear of crime per grid (DG).

3.3 Visibility Graph Analysis (VGA)

As studies indicate that severe crimes are relatively rare whereas minor ones are common in schools, the range of crime was extended to school violence and the students were told that even minor issues could be critical information. 2) Students marked spots where they felt fear of crime on their aerial photograph of their own school exterior areas. The number of spots was limited to three due to space limitations. 3) To define the degree of fear of crime, a 10-cm VAS was presented. Students were asked how fearful they felt at the spots, and marked an "X" on a 10-cm line to denote the degree of fear, with 0 cm being the least fearful and 10 cm being the most fearful. 4) Students wrote the reason for fear of crime at each criminal spot in an open-ended answer. They were asked to make their reasons as specific as possible.

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3.3 Visibility Graph Analysis (VGA)

For an analysis of the visibility of the exterior areas of elementary schools, the outer walls of the building and the fences of the schools were used (Fig.2.). Depthmap, which is a program made to perform VGA (Turner, 2001), was used in this study. Visibility graphs were created at a resolution of 1m * 1m for an approximation of a human scale (Pinelo and Turner, 2010). This yielded about 58,139 grids in exterior areas of all six schools. In addition, graphs of visual connectivity were created (in this study, the term 'connectivity' in VGA is expressed as 'visual connectivity' to distinguish it from other methods based on space syntax).

Unfortunately, as there are few related studies, it was difficult to determine the visible distance for VGA. For the exterior analysis, referring to previous studies (Desyllas et al., 2003, Piao et al., 2012) which posited the visible distance as 100m and the distance at which discerning body gestures as 450 feet (137m) (Spreiregen, 1965), this study used a visible distance of 100m. To investigate the effects of visibility on fear of crime, this study analyzed visibility in two ways: visual connectivity with no visible distance restriction (CON_NO) and visual connectivity with visible distances restricted to 100m (CON_RES). Fig.2. shows examples of VGA in these two ways.

3.4 Effects of Visibility on Fear of Crime Analysis

To compare the levels of the differences between the means of visibility where there was fear of crime
and where there was not, an independent-samples t-test was used. To use statistical methods, the 58,139 grids were separately coded according to whether or not fear of crime was felt.

In addition, it was necessary to adjust the various levels of visibility of the six schools to investigate the effects of visibility on fear of crime with a regression analysis. Therefore, the visibility value of each school was divided into 50 levels with equal intervals and recoded as an ordinal variable that ranges from 1 to 50. The number of spots for fear of crime, the sum of the degree of fear, and the number of grids were investigated in the 50 levels. When determining the number of levels which would be the sample size in the regression analysis, a previous similar study which used 50 rooms of the Tate Gallery in London (Turner et al., 2001, Turner and Penn, 1999) was referred to.

4. Results

4.1 Hot Spots for Fear of Crime in School Exterior Areas

The aggregated data for school exterior areas show a total of 858 spots for fear of crime. As shown in Fig.3., there were some hot spots of fear in school exterior areas. The rear areas of buildings; areas located near newly built buildings; areas between buildings; curved or recessed walls; parking areas; and playgrounds were hot spots. The figure also shows that the density and degree of fear do not necessarily mach. Fig.4. shows examples of hot spots for fear of crime in school exterior areas. The frequency of fear and the sum of the degree of fear were calculated at each level of the two dimensions of visibility (CON_NO and CON_RES), which were recoded with an ordinal variable ranging from 1 to 50. Figs.5. and 6. present the sum of values for the six schools, showing that the frequency and sum of values for the degree distribution are bimodal for the two visibility variables. This means that students felt fear not only in locations with lower levels of visibility but also in locations with high levels of visibility.

4.2 Visibility Graph Analysis in School Exterior Areas

There were a total of 58,139 grids in the exterior areas of six schools and the VGA of schools in terms of CON_NO and CON_RES dimensions are shown in Fig.7. The visibility analysis values of each school were also divided into 50 levels and Fig.8. shows the
sum of the grid frequency of the six schools at each of the 50 levels. The results for CON_NO and CON_RES were negatively skewed (or minutely bimodal) in shape. This means that school exteriors consist mainly of high visibility areas, although there are also some lower visibility areas.

### 4.3 Effects of Visibility on Fear of Crime in School Exterior Areas

In both CON_NO and CON_RES, when the visibility values of the grids where fear of crime appears and does not appear are compared, the mean of the former is lower than that of the latter (p < 0.01) (Table 3.).

The results from the regression analysis of the two visibility analysis values (CON_NO and CON_RES) and the two fear of crime values (DS and DG) are summarized in Table 4. In all cases, the regression analysis gives a much higher $R^2$ value in the quadratic models than in the linear models. Therefore, the correlations between visibility and fear of crime are more appropriate in the quadratic models which are upwards (‘U’ shaped-graph) compared to the linear models (McDonald, 2009) (Fig.9.). Furthermore, when the visible distance is restricted, the $R^2$ values were higher compared to the non-restricted values. Considering DS and DG, DG did not show significant differences in $R^2$ values compared to DS.

### 4.4 Reasons for Fear of Crime

It was found that about 95% (94.9% for CON_NO, 95.2% for CON_RES) of spots where students felt fear of crime were in the top and bottom 30% in terms of visibility (Table 5.). Therefore, to analyze reasons for fear of crime, visibility was divided into three categories: the bottom 30%, the middle 40%, and the top 30%. As shown in Table 5., in the low visibility area, human factors (31.2% for CON_NO and 31.4% for CON_RES) and space factors (34.3% for CON_NO...
5. Discussions and Conclusions

Generally, locations for which fear of crime was reported had lower levels of visibility compared to locations not associated with fear of crime, and it was similar to the results of previous studies (Andrews and Gatersleben, 2010, Fisher and Nasar, 1992, Loewen et al., 1993, Nasar and Fisher, 1993) which asserted the negative relationship between visibility and fear of crime. However, this study analyzed visibility with several precise quantitative analyses and found that where there was very high visibility, fear of crime rebounds in what can be shown as a U-shaped graph. These results support the findings of previous research (Lee et al., 2012) which found that fear of crime can occur not only in places with poor visibility but also in those with very good visibility. In other words, visibility exhibits duality in terms of fear of crime in environments. Environments with extremely low or high visibility are highly associated with fear of crime. This finding is contrary to the conventional theory of environmental criminology or CPTED, which asserts that areas with good visibility are safe from criminal behavior. This study investigated why students experience fear of crime in high visibility areas and compared these reasons with the causes of fear in low visibility areas; it was found that human factors (among human factors, ‘peers’ were the most frequent reason) had a much greater proportion in high visibility areas than in low visibility areas. It could be supposed that human factors associated with activities among peers could be an important clue to explain the rebound of fear of crime in the high visibility areas. Previous studies have also contended with the problems of open spaces in which people gather. Murota (2009) asserted that the network in an open space can strengthen intercommunication but can also raise safety concerns due to people passing through it. Kim and Moon (2013) also claimed that the flow of human traffic can have a negative side effect. Therefore, such high visibility areas (e.g., playgrounds) where people tend to gather could be criminal hot spots even though these environments meet the visibility factors of CPTED.

Although most exterior spaces of elementary schools are high-visibility areas, the hottest spots were behind the buildings areas which were low in visibility. Therefore, in order to position school buildings adequately, narrow paths behind buildings should be avoided, though if these paths are inevitable, as in a previous study (Kim and Ha, 2011), the fence that follows the path should be possible to see from outside of the school. Moreover, regarding the exterior areas of buildings to minimize spots related to fear of crime, the outer walls of school buildings should be straight.
without curves. In cases where new buildings must be added, the creation of places associated with fear of crime should be avoided.

A restriction on visible distance improves the coefficient of determination of visibility and fear of crime models. Unfortunately, there are few studies of visible distances, especially with regard to the relationship between visible distances and fear of crime. If more in-depth studies about visible distances are suggested, more valuable data related to visibility and fear of crime can be gained. To be specific, lighting and natural daylight can influence the visible distance.

Visibility was only slightly related to the degree of fear of crime. In other words, visibility does not heighten or lower the degree of fear of crime. It could be supposed that the multiple and combined elements suggested in the previous studies (Lee et al., 2012, Park and Ha, 2012, Yoo and Ha, 2011) — including human factors, vegetation, and darkness — all heighten the degree of fear as compared to visibility alone.

This study has several limitations. In exterior environments, although many studies (Donovan and Prestemon, 2012, Kuo and Sullivan, 2001, Lee et al., 2012, Troy and Grove, 2008) suggested that vegetation is related to crime, this study did not consider vegetation in the analysis because applying this element to a visibility graph analysis cannot be done accurately, and there were no clear criteria for determining whether certain vegetation interferes with visibility. In addition, as the children in the survey were too young to pinpoint the exact locations in which they feared crime, using a technological method such as a global positioning system (GPS) could improve the validity of the study (Sugihara et al., 2010).

This study provides the evidence of effects of visibility on fear of crime in environments, and builds on previous research about fear of crime and environments in a more precise manner through its use of automated quantitative analysis techniques. In addition, through its use of surveys completed by students, this study suggests substantial spots for fear of crime which teachers, designers and other school officials may not notice. In the long run, a reduced level of stress from fear of crime would improve the quality of the students' life (Li and Yao, 2013). Furthermore, the results of this study would help school environment designers to plan safer environments and improve existing environments by considering visibility conditions in an automated and systematic way.

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