Identification of Environmental Cues and Decision-Making Strategies of Residential Burglars

So-Yeon Park and Kyung-Hoon Lee*

Department of Architecture, Graduate School of Engineering, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul, 02841, Korea

Abstract: In this study, as a preliminary study for a development of a residential burglars' target selection model, previous studies on residential burglars' target selection were reviewed and analyzed in terms of methods and purposes of research, and the implications for future research were suggested by integrating the results of the review. Firstly, it seems that the experimental research method has many advantages for developing the target selection model at the house level compared to using crime data and conducting interviews or questionnaires. Secondly, virtual reality can be used as an effective tool in the experiment, since it allows researchers to construct the experimental environment without any constraint and enables participants to be completely immersed. Thirdly, although researchers in the field of architecture tend to mainly focus on deriving environmental cues that influence the decision of the burglar, decision-making strategies used by burglars when selecting targets should also be identified to develop a comprehensive model of burglars' target selection. Finally, considering the cognitive process of residential burglar, several research questions can be derived (i.e. 'What environmental cues do burglars consider when evaluating each environmental attribute?', 'What decision-making strategy do burglars use to evaluate each environmental attribute?', and 'What decision-making strategy do burglars use to make a decision on whether or not to commit burglary?').

Keywords: Residential burglary, target selection, environmental cues, decision-making strategies.

1. INTRODUCTION

The rapid increase of crime is one of the most critical social issues in Korea. The Korean Police Crime Statistics showed that 392.8 burglary crimes per 100,000 of the population occurred in 2016. This is equivalent to 11% of the total crime incidents, which shows that burglary is the most frequent crime after traffic, intellectual, and violent crimes. Furthermore, burglary is the crime most feared by the public [1], and its victims may suffer from not only the loss of stolen property but also the psychological effects such as fear of crime, trauma, and distress. However, burglary tends to be recognized as less serious than other types of crime, such as murder, robbery, and assault, since it targets private property rather than people, and only a few studies have been conducted on burglaries. A lack of understanding therefore arises of the burglars' decision-making process, their behaviors, and the situational and environmental backgrounds in which burglaries occur. This implies insufficient scientific and systematic evidence to make appropriate preventative measures against the occurrence of burglaries [2].

It is generally known that burglars make offending decisions rationally by evaluating costs and benefits resulting from their offenses using particular templates. This indicates that burglars make a decision to commit burglary based on certain criteria rather than deciding impulsively and irrationally. Therefore, if the burglars' cognitive strategies and environmental factors can be identified, a more effective crime prevention strategy can be established. The ultimate goal of this study is to develop the burglars' target selection model by identifying the decision-making process and environmental cues affecting the burglars' decision. As a preliminary research, the aim of this study is to review related theories and previous studies on burglars' target selection and to suggest implications for future research by integrating the results of the review.

The concept of burglary in this study is restricted to residential burglary of detached houses since residential burglaries occur most frequently among all the types of burglaries except for those that occur on the street, and more burglaries occur in detached houses than in apartments and multiplex houses among residential facilities. Also, the analysis unit of this study is mainly focused on architectural design elements at house level. The analysis units of previous studies on residential burglary can be divided into the neighborhood level (macro), the street level (meso) and the house level (micro). Since this study deals with architectural design elements as variables, it is appropriate to perform analysis at the house level in order to better examine the variables. It is widely known that a burglar initially selects a larger area such as a neighborhood according to his or her purpose, and gradually targets a specific street and a precise house

*Address correspondence to this author at the Department of Architecture, College of Engineering, Korea University, 145 Anam-ro, Seongbuk-gu, Seoul, 02841, Korea; Tel: +82-2-3290-3339; Fax: +82-2-921-7947;
E-mail: kh92lee@korea.ac.kr

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in the selected area [3]. Considering that burglars finally burglarize a target at the house level, the approach using a smaller spatial unit for analysis can make it possible to examine the decisions that burglars make when searching for a particular target.

2. LITERATURE REVIEW

In traditional criminology, the incidence of crime was usually explained according to offenders' characteristics as well as psychological, social, and economic factors. Since 1900, the importance of situational factors of crime has been emphasized, and the development of theory and related studies has been actively carried out by analyzing the environment, space, and community which attract or deter crime. Meanwhile, the concept of environmental criminology [4] emerged, which claims that crime can be explained by environmental factors rather than offender's characteristics. The representative theories corresponding to environmental criminology are the routine activity theory [5], the rational choice theory [6], and the crime pattern theory [7].

The routine activity theory considers that opportunities for crime occur in everyday routine activities, and crime occurs when the three conditions of a motivated offender, a vulnerable target, and the absence of a capable guardian intersect in space and time simultaneously in the course of daily activities.

The rational choice theory explains that offenders aim to maximize benefits and minimize costs and risks by evaluating all the possible cues given to them, as is evident in most forms of human behavior. According to Snook *et al*. (2011), offenders can weigh the possible benefits against costs resulting from an offending action and can then select the appropriate target that maximizes benefits and minimizes costs [8]. However, some researchers who oppose the rational choice theory have argued that evaluating every possible alternative and selecting the right alternative to get the most benefit is beyond human ability. They thus provided the 'limited rationality' perspective, which suggests that people may make 'fast and frugal' decisions using simple cues, especially when time, information, and resources are insufficient [8-10]. Several studies have shown that 'limited rationality' perspective better predicts the decision-making of general practitioners, magistrates, and residential burglars than the rational choice perspective [8, 11-13].

The crime pattern theory adds geographical elements, such as nodes, paths, and awareness space, to the routine activity theory. 'Nodes' represent places frequently visited, such as houses, schools, shopping malls. Offenders travel on 'paths' that connect 'nodes' in their everyday routine lives and, as they travel the same 'paths' frequently, the 'awareness space' is established. Within their 'awareness space', offenders search for suitable targets using their own criminal templates [14]. Based on this, the crime pattern theory explains why crime incidents are concentrated in particular areas, and provides a systematic way to analyze patterns of criminal behavior.

3. METHODS

This study focuses on the residential burglars' target selection at the house level. As a preliminary study on the development the burglars' target selection model, the following research was performed. First, the previous studies related to the decision-making of residential burglars were reviewed. The analysis of the previous studies was conducted in two aspects: (1) the research methods and analytical methods that were used and (2) the research purposes. Finally, the implications for future research were suggested based on the analysis of previous studies, in terms of research questions, research methods, and a plan for analysis.

4. ANALYSIS OF PREVIOUS STUDIES

4.1. Research Methods

4.1.1. Usage of Crime Data

Researchers in various fields, such as criminology, psychology, urban planning, and architectural design, have been conducting research to understand the behavioral and cognitive characteristics of burglars using various research methods. The typical approach is to use the crime data. Using the crime data as a dependent variable, researchers discover influential or correlational variables in social, economic, anthropological or environmental contexts through statistical analysis [15-20]. Although this method is meaningful as it allows analysis of the macroscopic level of the variables influencing burglary, it is difficult to explore variables at the microscopic level because of limitations of the data that can be acquired, and it is impossible to consider the crime that is not presented in the crime data. In addition, this method is limited since it relies on statistical data to be published by the government on socio-demographic and physical environment variables, which constrains researchers from including the variables they want to deal with.

4.1.2. Interview with Experienced Burglars

In some studies, interviews or questionnaires were conducted on incarcerated burglars or ex-burglars [2, 21, 22], which showed meaningful results since they measured burglars' behaviors and cognitive processes based on the actual criminal experience of participants. However, this method is often criticized for not being able to guarantee the authenticity and reliability of the information obtained from participants. According to Cornish and Clarke (1986), more professional burglars tend to exaggerate their criminal experience, and even the burglars who have already been sentenced tend to be reluctant to reveal their correct criminal experience because of the intrinsic nature of the crime and the risk of detecting additional crimes [6, 23]. In addition, generalizing research results is limited because each burglary incident is committed in a different situational and environmental background.

4.1.3. Experiment with Experienced Burglars

In order to overcome the limitations of research using interviews or questionnaires, several experiments on experienced burglars have been conducted [9, 24-28]. The aim of the experiments is usually to statistically determine the environmental or situational cues that influence burglars' target selection. For this purpose, an experimental participant, as a motivated burglar, is asked to navigate under various situational and environmental conditions virtually established by researchers. A participant is required to select the suitable target to commit burglary or to evaluate every object in terms of a burglary target, and the data gathered from participants are analyzed to determine the variables that influence burglars' target selections.

When experimental research methods were first introduced, virtual conditions were explained to the participants through vignettes, photos, or videos. Although using vignettes in order to give participants information is the most comfortable way to construct and to manipulate various detailed variables, participants find it difficult to fully immerse themselves in virtual conditions. In contrast, while using photos or videos can provide participants with some sense of immersion, it is difficult for researchers to combine variables intentionally, and ethical issues can arise because the actual environment needs to be photographed.

In recent years, improvements have been made in experimental methods. For example, the development of 3D technology makes it possible to create virtual environments very similar to reality, and using interactive simulations means participants independently decide what to view, where to go, and how long to stay. Some researchers recently conducted experimental research on burglary using virtual reality (VR) which can be relatively easily constructed through a game engine, such as unity and unreal [29, 30]. VR has many possibilities as an experimental research method because the participants can experience high realism, various static and dynamic variables can be applied, and the built environment can respond to the subject's particular behavior.

4.1.4. Usage of Agent-Based Model

Meanwhile, several studies based on an agent-based model (ABM) have been conducted to predict burglary through using agents to analyze the correlation between environmental cues and burglars' behavioral characteristics [14, 21, 31]. An ABM is a computer simulation that involves 'agents' who are able to make decisions autonomously. Each agent represents a virtual 'person' into which behavioral rules have been input, and behaves accordingly. In a specific virtual environment, agents are placed, and each agent interacts with surrounding environments and other agents. This model simulates the real behavior of offenders and improves the realism of the environment [31]. However, since the cognitive process of the burglar has not been clarified, the behavioral rules input in agents are limited and fragmentary. If research results on the burglars' behavioral characteristics and cognitive processes are accumulated, they can contribute greatly to burglary research using ABM.

4.2. Research Purpose

4.2.1. Clarifying Burglary Influential Variables

A typical approach to understand the behavioral characteristics of burglars is to identify the physical, anthropological, and social factors that influence the burglar's decision to commit a crime and the importance of each factor. In the field of architecture, researchers have especially focused on establishing the basic knowledge of crime prevention through environmental design (CPTED) by clarifying environmental cues that affect crime decisions [18, 21, 26]. These studies were conducted using various statistical analysis methods, such as descriptive statistics, correlation analysis, regression analysis, and t-test. The dependent variable was set as the decision of whether to commit burglary or a preference as a

Table 1: Environmental Cues Influencing Burglars' Decision-Making

Environmental Attributes			Environmental Cues
Risk	Occupancy	by people	Parking, Lighting inside, Mailbox
		by proxies	Alarm, Dog
	Visibility	front	Street width, Fence visibility
		side	Number of adjacent neighbors, Fence visibility
		common	Front setback, Vegetation
	Security		CCTV
	Escape	over the fence	Side gate, Fence height
		away from the house	Number of adjacent streets, Adjacent hill or empty lot, Crossroads distance
Ease	Accessibility (to the yard)	fence	Fence height, Security Fence
		side gate	Side gate
	Accessibility (to the building)	front door	Window adjacent to front door
		1st level window	Window accessibility, Window security bars
		2nd level window	Balcony, Pipeline adjacent to window
Reward	Profitability		Building size, Type of parked car, Exterior finish

burglary target, and the independent variables were set as various environmental cues. Table **1** shows the environmental cues that are typically mentioned in many studies. Environmental variables, which are independent variables, can be divided into two levels: (1) the 'environmental cues' including the level of planning (e.g. the height of the fence, the installation of CCTV, accessibility of windows, etc.) and the situational condition (e.g. whether a mailbox is full, a car is parked, a light is on, etc.), and (2) the 'environmental attributes' that categorize the environmental cues depending on their characteristics.

4.2.2. Developing Burglary Risk Assessment Model

Some researchers have studied the development of a risk assessment model for burglary. Kang and Lee (2010) proposed the Multi-Layered Risk Assessment (MLRA) method based on GISs which includes four categorized indexes, such as spatial configuration, land or architectural use pattern, street characteristic, and socio-demographic variables, to measure burglary risk grades at street level [32]. Agarti (2015) focused on the vulnerability of buildings to evaluate their probability of being burgled. He suggested a semi-quantitative evaluation method which combines qualitative assessment and coefficients derived from statistical analysis [33].

4.2.3. Identifying Burglars' Decision-Making Strategies

In addition to focusing on the factors that influence the burglar's decision-making, some researchers have studied the decision-making process or cognitive strategies taken by burglars when searching for suitable targets. Homel, Macintyre, & Wortley (2013) performed an experiment to clarify the amount of information on the target that was selected and in what order to select the information. They then presented the decision tree model of the burglar based on the result of the experiment [9].

Retamero and Dhami (2009) conducted an experiment with two participant groups (i.e. experienced burglars and police officers as an expert group, and graduate students as a novice group). They used two types of decision-making strategies to explain which strategy is more likely to be employed when deciding to commit burglary. The first strategy used in this study is a weighted additive linear model (WADD), which calculates the sum of all cue values that are multiplied by the weights of each cue for each target and finally selects the target with the highest score. This strategy assumes that people weigh and integrate various cues in a compensatory way when making decisions. Another strategy is the take-the-best heuristic [34], which is based on the 'limited rationality'

perspective. Take-the-best heuristic is a model used when selecting one among binary alternatives through discriminating the value of one or two cues which have the highest cue weight. This is a non-compensatory strategy because it makes no trade-offs between cues. As a result of this study, it was found that the target selection of the expert group was better predicted by the take-the-best heuristic and, in contrast, the target selection of the novice group was better explained by WADD [13].

Snook, Dhami, and Kavanagh (2011) studied a similar experiment comparing two types of decision-making strategies (i.e. Franklin's Rule as a compensatory model, and Matching Heuristic as a non-compensatory model) by clarifying the ability of one decision-making strategy to capture burglars' decisions on the occupancy of targets compared to another strategy. Franklin's Rule predicts a decision by comparing the threshold value and the sum of all the cue values multiplied by the weight of each cue. If the sum is greater than or equal to the threshold value, focal decision (in the case of the occupancy decision, 'unoccupied' is the focal decision) is adopted, and if the sum is less than the threshold value, non-focal decision (in the case of the occupancy decision, 'occupied' is the non-focal decision) is adopted. While Franklin's Rule considers all the cues, Matching Heuristic ranks the cues according to the utilization validity of each cue and predicts a decision based on the value of the cue with the highest utilization validity. The utilization validity refers to the proportion of the number of cases with the critical value corresponding to the focal decision. Critical value indicates the cue value (e.g. 'the vehicle is present' or 'the vehicle is absent' for the 'parking' cue) that most frequently corresponds to the focal decision. For example, if more houses without vehicles were judged to be unoccupied, then the critical value for parking cue will be 'absent'. The maximum number of cues to be searched is determined by calculating the ability to accurately predict decisions. The result of this study showed that the Matching Heuristic predicted the burglars' occupancy decisions significantly better than Franklin's Rule [8].

4.2.4. Considering Burglars as Experts

To focus on the conspicuous characteristics of burglars as experts in their jobs, some researchers compared burglars with the general public (e.g. students), experts of the crime-related field (e.g. police officers), or other type of offenders [24, 25, 35]. According to the characteristics of burglars described in various studies, they tend to make intuitive and automatic decisions, have a good memory of crime-related environmental cues, and differ in their response to environmental characteristics [27].

5. IMPLICATIONS FOR FUTURE RESEARCH

5.1. Research Questions

In the field of architecture, studies on burglary focus primarily on the identification of environmental cues influencing the burglar's decision-making or

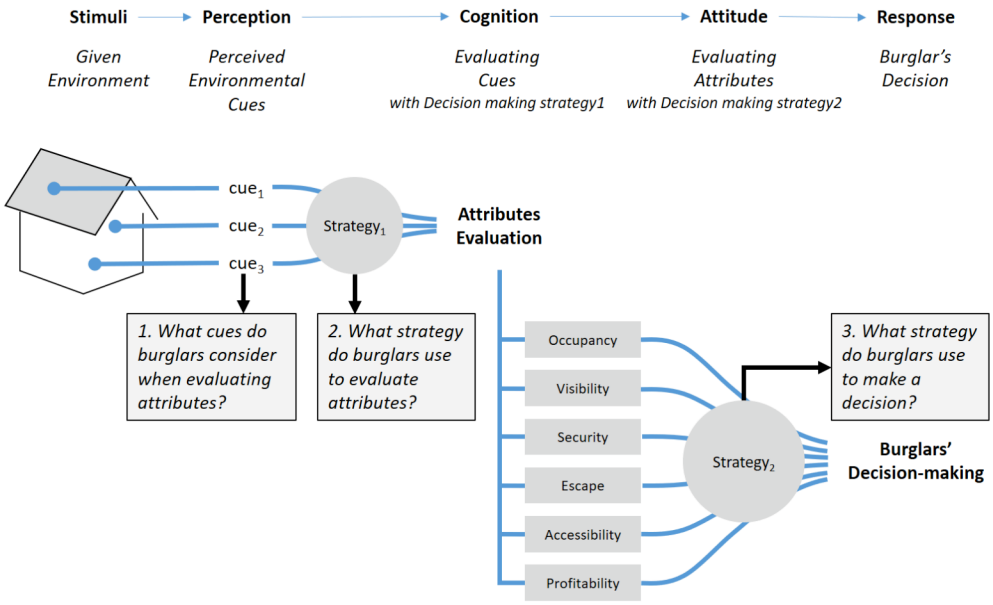

Figure 1: Cognitive Process of Residential Burglar.

development of the burglary risk assessment model by combining the derived cues. Most of the studies assume that a burglar follows the same rational decision-making process as a non-burglar, and has the ability to take into account all the cues and to evaluate all possible alternatives. However, as some studies have already shown, burglars may use simpler cues and adopt a more intuitive decision-making strategy because of the lack of time and information. Therefore, to develop a burglars' target selection model, it is necessary to clarify the decision-making strategy used by burglars as well as the number and type of environmental cues that are considered.

Figure **1** illustrates the cognitive process used by a burglar when determining whether or not to commit burglary at a certain house through evaluating a given environmental stimulus. First, a burglar perceives several environmental cues which are valuable to consider when evaluating each environmental attribute (i.e. occupancy, visibility, security, escape, accessibility, and profitability). He or she then uses a certain decision-making strategy (i.e. $strategy_1$), such as WADD or Matching Heuristic, to evaluate each attribute. Subsequently, he or she calculates the results of the evaluation of attributes in order to make a decision of whether or not to commit the burglary, using another decision-making strategy (i.e. $strategy_2$). From the cognitive process of the residential burglar, the following research questions can be derived.

- What environmental cues do burglars consider when evaluating each attribute?
- What decision-making strategies do burglars use to evaluate each attribute?
- What decision-making strategy do burglars use to make a decision on whether or not to commit burglary?

5.2. Research Methods

For behavioral researchers, the best research method is to observe the behavior of real people in real time. In the case of studies on the behavior of offenders, however, observational research cannot be performed due to ethical issues and safety concerns. Even though the research using the crime data is limited as it is impossible to consider unreported crimes and to obtain the crime data at the desired spatial level, the reliability of the data is relatively high in comparison with the research methods which depend on the past memories of experienced burglars, such as interviews and questionnaires. However, it is hardly possible to obtain crime data on the burglary cases of individual houses, especially in Korea, and to accurately understand the dynamic circumstances of the crime scene.

Experimental research has many advantages since the researcher is able to manipulate the experimental situation or environment considering the purpose of the research, and to observe the trajectory and behavior of the participant in the process of selecting the target. However, a constant question arises regarding the degree to which the participants can be immersed in the experimental situation or environment, and whether they behave in the virtual environment in the same way as they do in the real environment.

In this regard, the rapidly evolving 3D simulation technology is expected to contribute to solving the limitations of the existing experimental method by creating a 3D environment with high realism. Moreover, the 3D environment can be relatively easily built as a VR through game engines such as Unreal and Unity, while VR related devices, such as HMDs and VR treadmills, are gradually being commercialized. These developments in VR technology increase the potential of criminological research using experimental methods. Nee *et al*. (2015) performed an experimental study to investigate whether there is a difference between the virtual environment and the real environment in the residential burglar's offending behavior and decision-making; the results showed that burglars behaved almost the same in both environments [29]. Therefore, if a virtual environment with high realism can be constructed, it could be an alternative to studying the actual searching process and offending behavior of the burglar.

Given these concerns, it is considered that the experimental research using VR as a tool has significant potential as a research method to clarify the environmental cues and decision-making strategies used by the residential burglar when searching for a target at the house level. In addition, it would be possible to objectively observe and quantitatively evaluate the participants' real-time reactions and behaviors according to various combinations of environmental cues in the virtually manipulated experimental environment.

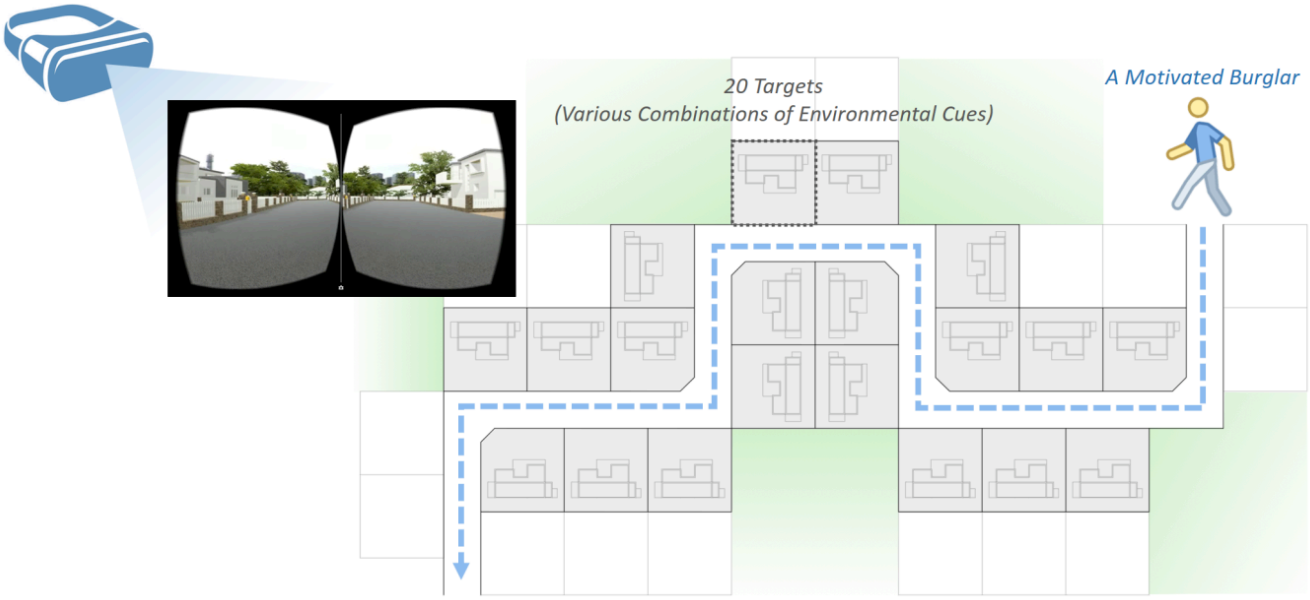

Figure 2: Plan for building a virtual environment for an experiment.

Figure **2** shows a possible plan to build a virtual environment by deploying 20 houses with various cues combined, specifically built for the experiment. In this experimental environment, the participants who wear the HMDs walk along a path and evaluate each house placed in the environment.

5.3. Plan for Analysis

It is necessary to identify the environmental cues that influence the burglar's decision-making and to clarify how the burglar evaluates these environmental cues using a decision-making strategy to develop the residential burglars' target selection model. To investigate the burglar's decision on residence

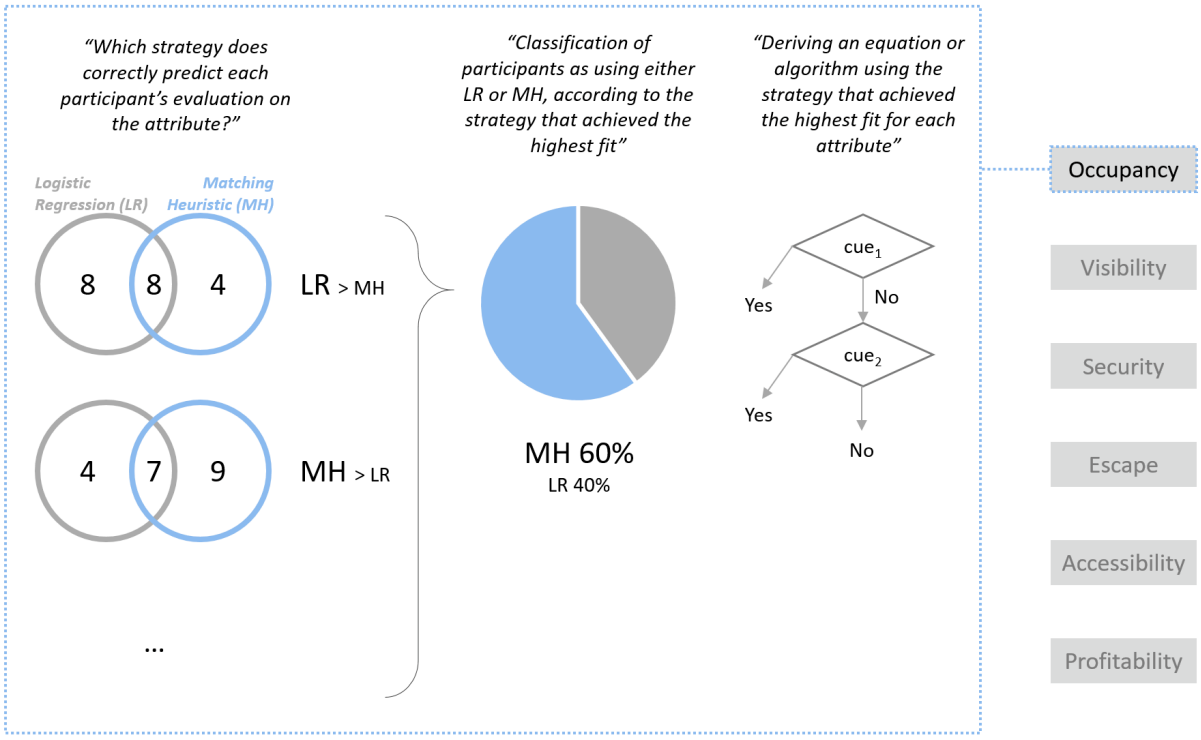

Figure 3: Framework for deriving strategy$_1$ used to evaluate environmental attributes.

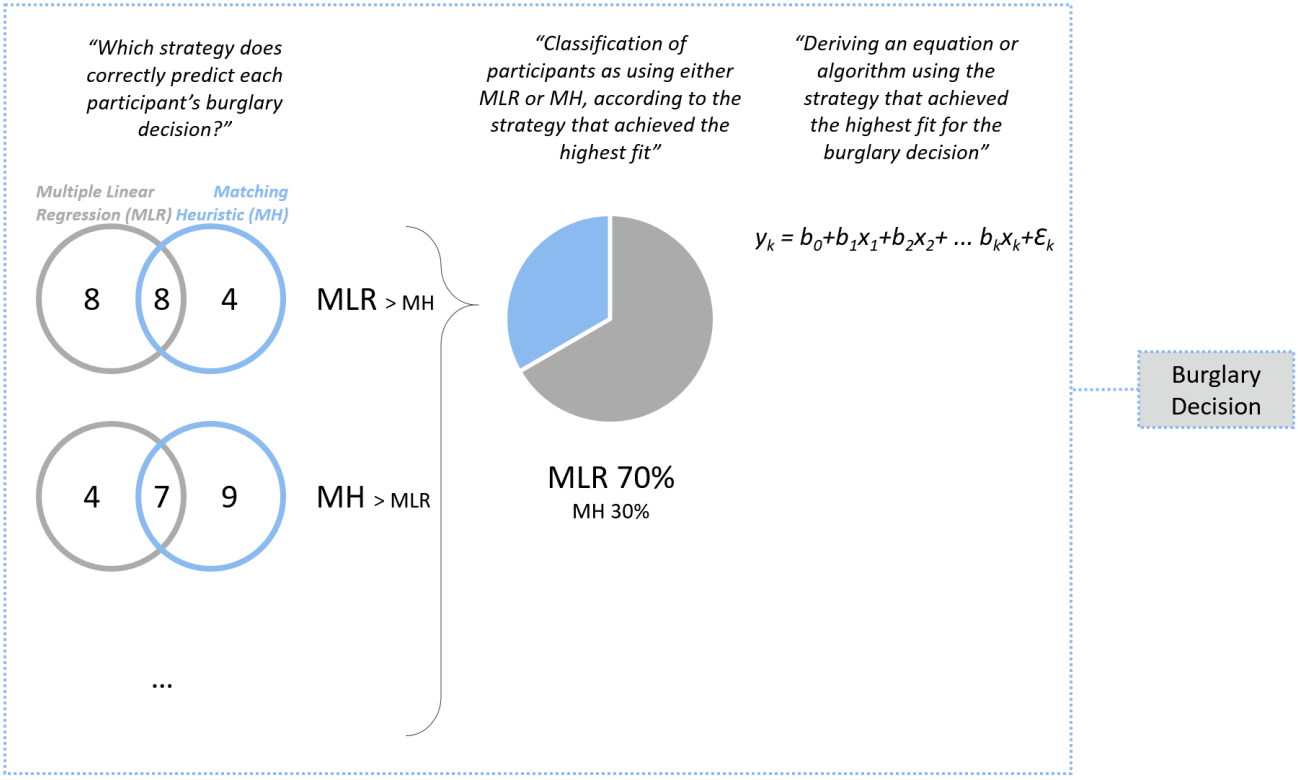

Figure 4: Framework for deriving strategy$_2$ used to determine the burglary action.

occupancy, Snook, Dhami and Kavanagh (2011) conducted an experiment with sentenced prisoners who had been convicted of at least one burglary. Twenty photographs of houses which have various values in 8 cues (i.e. vehicle, security system, windows above ground level, curtains above ground level, curtains at ground level, landscaping to hide behind, dead-bolt, and attached garage) were shown to the participants as stimuli, and they were asked to decide whether or not the house was occupied. All the data from the 20 cases for each participant were computed by Franklin's Rule and the Matching Heuristic to identify the strategy that can better predict the participants' decision [8]. The analytical method used by Snook, Dhami and Kavanagh (2011) makes it possible to simultaneously discover the environmental cues and the decision-making strategies that participants use mainly. Although they were only interested in decision-making on residence occupancy, if studies on other environmental attributes, such as accessibility, visibility, escape, profitability, and security, are conducted, a wider understanding of burglars' decision-making can be reached. Considering the type of data acquired and experimental methods adopted, Franklin's Rule can be replaced by Logistic Regression or Multiple Linear Regression, and the take-the-best heuristic or any other heuristic decision-making strategy can be considered as an alternative for the Matching Heuristic.

Figures **3** and **4** show the framework, for future research, related to the analysis of the acquired data from the experiment. Figure **3** illustrates the process of deriving decision-making strategies (strategy$_1$) used to evaluate each environmental attribute by integrating perceived environmental cues, and the development of a decision-making model for each environmental attribute based on the derived strategy. Figure **4** shows the process of deriving the decision-making strategy (strategy$_2$) that is used to determine the burglary action, and the final burglary decision-making model based on the derived strategy.

CONCLUSION

This study was conducted to establish a basis for developing the residential burglars' target selection model in detached houses. To do this, the related theories were examined and the previous studies were analyzed in terms of research methods and research purposes.

Based on the analysis of the previous studies, it was shown that, compared to using crime data and conducting interviews or questionnaires, the

experimental research method has many advantages for developing the target selection model by drawing quantitative data from the microscopic point of view. Using 3D simulation and VR technology which have developed rapidly in recent years, it is expected that many improvements will be made in the methodological aspects of experimental research. A tendency has recently been shown, especially in the field of architecture, to focus mainly on deriving environmental cues that influence the decision of the burglar to commit a crime, and to analyze data based on the perspective of the rational choice theory. In order to more accurately reflect the decision-making of the burglar, it is necessary to identify the decision-making strategies used by the burglar in the process of selecting a target.

Based on the results of the analysis, the implications for future research were proposed from the perspective of research problems, research methods, and a plan for analysis. If a follow-up research is carried out in the near future based on the implications suggested in this study, it will be possible to develop a more comprehensive and realistic model of the residential burglars' target selection.

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