Received: 19 November 2017 | Revised: 16 January 2019 | Accepted: 25 January 2019

DOI: 10.1111/1745-9125.12210

CRIMINOLOGY

ARTICLE

Learning on the job: Studying expertise in residential burglars using virtual environments*

Claire Nee[1] | Jean-Louis van Gelder[2] | Marco Otte[3] | Zarah Vernham[1] | Amy Meenaghan[1]

[1]Department of Psychology, University of Portsmouth, Portsmouth, U.K.

[2]Faculty of Behavioural, Management and Social Sciences, University of Twente, Enschede, the Netherlands

[3]Network Institute,VU University, Amsterdam, the Netherlands

Correspondence
Claire Nee, Department of Psychology, University of Portsmouth, King Henry Building, King Henry 1st St. Portsmouth, PO1 2DY, U.K.
Email: claire.nee@port.ac.uk

Funding information
British Academy, Grant/Award Number: SG151138

*We wish to acknowledge the Amsterdam Law & Behavior Institute (A-LAB), University of Portsmouth, and the British Academy for funding this project; the National Offender Management Service (now HMPPS) for granting permission to undertake the research in U.K. prisons; students who helped with data collection: Kayleigh Cooper, Josh Cole, and Jennifer Evans; and our participants and staff in prisons who went above and beyond the call of duty to assist us during a challenging time in the U.K. prison service.

Abstract

In this article, we describe a quasi-experiment in which experienced incarcerated burglars (n = 56), other offenders (n = 50), and nonoffenders (n = 55) undertook a mock burglary within a virtual neighborhood. We draw from the cognitive psychology literature on expertise and apply it to offending behavior, demonstrating synergy with rational choice perspectives, yet extending them in several respects. Our principal goal was to carry out the first robust test of expertise in offenders by having these groups undertake a burglary in a fully fledged reenactment of a crime in a virtual environment. Our findings indicate that the virtual environment successfully reinstated the context of the crime showing clear differences in the decision making of burglars compared with other groups in ways commensurate with expertise in other behavioral domains. Specifically, burglars scoped the neighborhood more thoroughly, spent more time in the high-value areas of the crime scene while traveling less distance there, and targeted different goods from the comparison groups. The level of detail in the data generated sheds new light on the cognitive processes and actions of burglars and how they “learn on the job.” Implications for criminal decision-making perspectives and psychological theories of expertise are discussed.

KEYWORDS

burglar decision making, crime prevention, expertise, rational choice, virtual reality

> *“It’s like anything, like doing crosswords regular, especially from the same paper, I get to know what kind of cryptic clues the guy writes, it’s like, it’s a matter of practice. So if I’m regularly doing burglaries, I get a lot more quicker and better at what I’m doing.”*
> *– Burglar #23*

It has been powerfully argued that crime is easy, does not require specific skill sets, and is predominantly driven by a lack of self-control and quick reward (Gottfredson & Hirschi, 1990; Pratt & Cullen, 2000). Few researchers will argue with the idea that most “typical” acquisitive offenders lead chaotic lives and have low educational attainment, poor employment records, histories of drug abuse, relationship difficulties, and so on (Farrington & Welsh, 2007). This picture of the dysregulated offender may have overshadowed the fact that at least certain types of crime benefit from advanced skill sets (Grasmick, Tittle, Bursik, & Arneklev, 1993). Consider the significant technical knowledge and skill associated with computer hacking (Holt, Bossler, & Seigfried-Spellar, 2015); the competent interpersonal skill displayed in certain forms of identity theft (Vieraitis, Copes, Powell, & Pike, 2015); or the planning, grooming, and deception required to elude detection in the predatory child molester (Fortune, Bourke, & Ward, 2015; Ward, 1999). Such “expertise” has also been reported in social cue processing in street criminals (Topalli, 2005); the procedural scripts of arsonists (Butler & Gannon, 2015); the practiced coercion and control used in the planning and execution of murder (Brookman, 2015), domestic abuse (Day & Bowen, 2015), and rape Ó Ciardha, 2015; and finally the perceptual and procedural scripts of carjackers (Topalli, Jacques, & Wright, 2015).

In this article, we argue that expertise develops in offenders as they operate on the job in ways similar to expertise development in legitimate activities, and that a better understanding of this maladaptive form of competence can extend our knowledge of offender decision making in important ways. As part of a program of research that has become known as the “Virtual Burglary Project,” we use a virtual environment to test several assumptions related to the nature of burglar expertise and decision making generated from previous studies and established decision-making perspectives while shedding alternative light on the thesis that offending involves little skill.

We aim to contribute to the literature in different ways. First, we draw from cognitive and social psychology research and theory on expertise and apply it to offender decision making. We argue that our approach is complementary to rational choice perspectives of offender decision making but extends such perspectives in several consequential respects. Expertise augments the functional description of decision making by adding a deeper explanatory level involving unconscious and automatic processes, which as the findings from ample research bear out, are fundamental drivers of human behavior. In doing so, we explain how experience with offending increases offense-related knowledge and skill and, as such, how offenders “learn on the job.” Second, we intend to demonstrate the value of using virtual environments to improve the study of offender decision making. We show how this approach offers a series of new possibilities to study offending behavior that could lead to a step-change in our understanding of crime and how to prevent it. We capitalize on the unique opportunity of testing our approach directly among the target group, incarcerated burglars, and compare their behavior with a sample of nonburglar offenders and a matched sample of nonoffenders.

We first summarize the literature on expertise. We then apply the expertise paradigm to criminal decision making and theorize about the development of expertise in offenders. Next, we set out our hypotheses and describe the research design and methods. After presenting the findings, we discuss implications for theory, future research, and crime prevention.

1 | EXPERTISE IN COGNITIVE PSYCHOLOGY

Expertise refers to the skills and knowledge an individual develops through learning and concerted practice in a particular domain and can be conceived of as a continuum running from novices to masters (Chi & Bassok, 1989). The cognitive processes and consequent behavior of experts in that domain are demonstrably superior to novices, in the sense that they are faster, more cognitively economical, triggered automatically in relevant environments, and based on considerable experience and honing of skill over time (Ericsson, 2006). Although it is rare for individuals to reach the extreme end of proficiency (Ericsson, 1996; Montero, 2016), numerous examples of acquired expertise, such as learning a new language, or how to drive a car, can be seen at the lower end of the expertise continuum and are within the grasp of ordinary people, including, we posit, offenders. Importantly, the findings from a considerable body of research indicate that an expert, seemingly irrespective of the domain in which he or she operates (e.g., music, chess, medicine, and carjacking), processes information in relation to that domain in a way that is different from and distinguishable to a novice in that field.

1.1 | Elements of expertise

Three features in particular underpin expertise: 1) *preconscious attention* resulting in a heightened situational awareness of cues relevant to the domain of expertise (Bargh, 1994), 2) the development of dense and interconnected *cognitive schemas* stored in long-term memory (Fiske & Taylor, 1991), and 3) *automaticity* in decision making and behavior (Logan, 1988). These elements constitute the core mechanisms underpinning behavioral proficiency and go beyond functional or predictive models in which associations between factors and their outcomes are simply described (Potochnik, 2017), thus, adding to the valuable foundations laid by rational choice perspectives.

The first element of expertise allows for the unconscious scanning of the environment for triggers associated with reward and threat (e.g., Bargh, Gollwitzer, Lee-Chai, Barndollar, & Trötschel, 2001; Klein, 1993). Evidence from neuropsychology indicates that these processes, which are linked to self-preservation, allow for an eternal vigilance (Bargh, 1994, p. 5) and are chronically accessible (Bargh, 1994, p. 4). That is, they are permanently operative and difficult, if not impossible, to “turn off” (Bechara & Damasio, 2005) and facilitate a growing ability to attend automatically to and prioritize meaningful cues relevant to one’s expertise (Ericsson & Kintsch, 1995). Experts become increasingly skilled at recognizing, encoding, and storing information that could *potentially* be important in their future decisions, which allows for instant and superior evaluation of situations/encounters (Endsley, 2006). Those cues, not acted on at the time, are either rejected or enrich cognitive schemas stored in long-term memory, to be acted on later.

The second fundamental feature of expertise is the development of cognitive schemas through “chunking.” These memory shortcuts involve the structure and organization of chunks of information in long-term memory. They comprise abstract, prototypical maps or mini-recipes regarding how to respond in a situation, given particular regular and familiar configurations of cues in our environment (Fiske & Taylor, 1991). Their principle function is to simplify decision making and behavior, freeing up space in working memory and cognitive resources to deal with more conscious and immediate issues (Shanteau, 1992). As novices commence practicing a skill (e.g., learning to play the piano), they become increasingly attuned through trial and error to environmental cues that represent successful choices and decisions, as well as to those that are less useful and can be ignored in the future. As skill develops, the individual begins to chunk together in memory patterns of recognition and knowledge about how to respond given certain cues, allowing him or her to operate more quickly and efficiently until these processes become automatic.

Automaticity is the third feature underpinning expertise. With repeated practice, abilities become automatic and do not require explicit conscious attention anymore (e.g., being able to drive without thinking about it or playing a tune without mentally instructing oneself which notes to play). Once a schematic set of information is learned and stored in long-term memory, relevant cues and triggers in the environment result in instantaneous evaluation and action. The results of experimental work by, for instance, Bargh (1994), Kahneman and Tversky, (1979), and Shiffrin and Schneider (1977) has shown that automaticity, similar to preconscious attention, is unintentional, uncontrollable, highly resource efficient, and occurs outside conscious awareness. Furthermore, an advantage of automaticity, like cognitive schemas, is that it frees up cognitive resources to tackle other tasks, including flexibly responding to the unexpected. Although much of expert decision making is beneath conscious awareness, consciousness is construed as a continuum rather than as an all-or-nothing phenomenon, which is in line with contemporary cognitive-psychological explanations (Morin, 2006).

In sum, these core features underpinning expertise allow for increasingly accurate, automatic, and unconscious recognition of relevant stimuli and instantaneous action, faster coding of familiar stimuli, and the ability to multitask resulting in improved performance.

The psychological study of expertise has evident parallels with research on offense specialization. There is ongoing debate regarding whether offenders specialize in one type of crime or whether they are best seen as generalists (DeLisi, Nelson, Vaughn, Boutwell, & Salas-Wright, 2016; Fox & Farrington, 2016; Monahan & Piquero, 2009). This issue is relevant for the present purposes as an absence of specialization could limit the extent to which offenders can build up significant expertise through repeated learning in a specific criminal domain. Alternatively, from an expertise perspective, different types of offending may also require similar “transferrable” skill sets and, in this respect, represent a single domain or overlapping domains of expertise. For example, expertise in confrontational crime could allow for transmittable skills between offenses such as carjacking and street robbery but not others such as pickpocketing.

Overall, few findings from research indicate that experienced offenders restrict themselves entirely to a single type of crime, yet a wealth of research findings reveal at least some level of specialization (DeLisi et al., 2011; Sampson & Laub, 1993; Spelman, 1994), particularly for property offenders as they get older (Armstrong, 2008; Nieuwbeerta, Blokland, Piquero, & Sweeten, 2011; Paternoster, Dean, Piquero, Mazerolle, & Brame, 1997). In sum, it seems that specialization occurs, allowing expertise to accrue, particularly with respect to burglars. Some limited expertise may be seen in nonspecialist offenders too as a result of their more confined practice in each crime.

2 | BURGLAR AS AN EXPERT ON THE JOB

In line with findings reported in the expertise literature, there are indications in previous work on the journey to crime and target selection that burglars routinely scan the environment in a semiconscious way during their daily activities and have a heightened awareness for cues that signify a vulnerable target. Much of this earlier work is rooted in the rational choice (Cornish & Clarke, 1986) and routine activities (Cohen & Felson, 1979) perspectives. According to rational choice perspective, a "bounded rationality" (Cornish & Clarke, 1986; Johnson & Payne, 1986) in offender decision making indicates the use of heuristics based on prior learning, to maximize gain and minimize risk in their offending behavior. The routine activities model describes the habitual processing of cues denoting the vulnerability of targets during the offender's daily routines and activities, stored for later crimes.

Clarke and Cornish (1985, p. 147) started out their seminal piece on rational choice arguing that most theories about criminal behavior have tended to ignore the offender's decision making, the conscious thought processes that give purpose to and justify conduct, and the underlying cognitive mechanisms by which information about the world is selected, attended to, and processed. The rational choice perspective provides the theoretical basis of a series of situational perspectives, such as situational crime prevention and crime pattern theory (Reynald & Leclerc, 2018), yet restricts its scope mainly to how cognitive biases and the use of heuristics influence criminal choice behavior. As Van Gelder, Elffers, Reynald, and Nagin (2013) observed, since its introduction in the 1980s, it has received only sparse updating, and major advances in the study of information processing and decision making have gone primarily unnoticed. Incorporating elements from expertise models can extend rational choice perspectives and enhance our understanding of offending by explaining in greater detail how experience and learning "on the job" affect offender decision making. Additionally, rather than focusing on how cognitive limitations hamper decision making, it demonstrates how improved cognitive functioning as a result of practice and experience can render offenders more proficient, a thus far little explored area in crime research.

2.1 | Indications of expertise in burglars

We argue that as a functional model with a focus on the phases of decision making and the constraints that bind it, the rational choice perspective cannot provide a deeper understanding of the roles that attentional mechanisms, knowledge structures, and automatization processes play in generating skilled offending behavior. Perhaps more importantly, whereas rational choice perspectives are focused on conscious and deliberate processes, advances in cognitive psychology research have highlighted the importance of *unconscious* and *automatic* processes in guiding decision behavior (e.g., Kahneman, 2011). For example, competent burglars have described spending their free time "scouting" for opportunities (Shover, 1973, p. 504), "half-looking" (Wright & Decker, 1994, p. 80), and "scoping" potential properties to burgle on their way home, neither consciously paying attention to it nor ever deliberately turning this process off. Cromwell, Olson, and Avary (1991, p. 50), for example, described the "journeyman" who searches out and creates opportunities based on systematic and automatic recognition of environmental cues signifying gain and low risk. The direct relationship found between burglars' journey to work and target choice (Rengert & Wasilchick, 1985) indicates increased familiarity of the environment closer to home, allowing for richer expert schemas to build up.

In response to photos and videos of dwellings, burglars in Bennett and Wright's (1984) study gave spontaneous accounts of the visual cues they used to discriminate between vulnerable targets and others, highlighting the phased nature of decision making. These included noticing the relative ease of access to a property at the rear (for lower visibility), open windows, or a better maintained property indicating a more lucrative outcome from the burglary.

Next to qualitative work with active and imprisoned burglars, the findings from a limited amount of experimental research have shown significant differences between burglars and comparison groups. By using control groups of offenders without burglary experience, police officers, students, and matched nonoffenders, Logie, Wright, and Decker (1992) and Wright, Logie, and Decker (1995) demonstrated superior recognition memory for burglary-related environmental cues in young burglars in response to photos of houses, with burglars being more competent than other offenders, who in turn were more proficient than police officers, followed by students. The findings from these studies strengthen the argument that some offense specialization, and consequently expertise, accrues in burglars in comparison with other groups and indicate a sliding scale of expertise as a function of learning. Clare (2011), in comparing experienced and novice burglars, found both perceptual (recognition of higher value goods) and procedural (more skilled against all potential targets) expertise in more practiced participants. Furthermore, Nee and Taylor (2000) identified superior navigational strategies and recognition of cues denoting layout, access, affluence, and security of burglars in comparison with householders. In using the expertise paradigm, these findings suggest the superior activation of schemas allowing for the automatic enactment of crime, in addition to heightened appraisal and recognition. Recent interviews with burglars indicate that as expertise accrues, fast and frugal heuristics requiring fewer cues are engaged (Garcia-Retamero & Dhami, 2009; Homel, Macintyre, & Wortley, 2014; Snook, Dhami, & Kavanagh, 2011), allowing for more instantaneous appraisal of relative gain, topographical access, occupancy status, and security issues associated with a potential target.

In sum, we have learned that uppermost in the expert burglar's appraisal of a property are cues denoting relative gain (such as décor and cars), the degree of detachment from other properties (signifying a stealthy appraisal, usually increased cover and often value), the amount of side and rear access (for cover and escape), and lack of occupancy (lights, windows, blinds; Cromwell et al., 1991; Nee & Taylor, 2000; Wright & Decker, 1994). Security cues are usually downgraded as weak spots can be found because of human fallibility (Clare, 2011; Nee & Meenaghan, 2006). Once inside, experienced burglars target unidentifiable, valuable, and portable goods (Clare, 2011; Maguire & Bennett, 1982; Nee et al., 2015). Offender-based findings indicating the "perfect" burglary target have been supported by numerous studies in which the features of burgled versus nonburgled properties are compared, the most innovative using data from Google Street View (Langton & Steenbeek, 2017).

The findings from these quantitative analyses of the spatial, temporal, and architectural aspects of completed burglaries offer additional support for the accumulation of expertise in burglars. Study results from various countries indicate consistency in location choice, times, and features of the properties targeted for burglary, describing "cognitive templates," which resemble schemas, and "awareness space" and "idiosyncratic awareness," which denote increased familiarity with the environments that burglars target (e.g., Bernasco & Luykx, 2003; Bernasco & Nieuwbeerta, 2005; Brantingham & Brantingham, 1975; Elffers, Reynald, Averdijk, Bernasco, & Block, 2008). Together, these findings demonstrate initial declarative support for a model of expertise in offenders (Nee & Ward, 2015). A more recent approach to move the study of offending processes onto a more sophisticated and incisive level of enquiry involves the use of virtual reality (VR). Next, we review preliminary work using VR and how it has begun to help us understand competence in burglars prior to describing the current study.

2.2 | Previous burglary research using virtual environments

In two recent studies, researchers have explored the potential of virtual environments to study burglary behavior and provide the basis for the current research endeavor. In the first study, Nee and colleagues (2015) explored whether participants would behave comparably in a real house versus a simple, virtual simulation of the same house. Six experienced ex-burglars and an equal-sized control group of university students undertook mock burglaries in both settings. The results show that all participants approached the burglaries in the two environments almost identically. Furthermore, although rudimentary, observations of behavior in both settings clearly distinguished between the approaches of the ex-burglars and the control group. As predicted, the experienced group entered and exited at the rear (as a result of enhanced appraisal and recognition of cues); used cleaner, more systematic routes through the house (superior enactment via schema activation) focusing on high-value areas; and stole fewer and more valuable items. Novices entered at the front, wandered haphazardly through the house, and were less discriminate regarding the items they stole, resulting in a less valuable haul. The range of behaviors recorded was considerably more varied in the control group, indicating less skill and script-like knowledge in relation to the burglary.[1]

To build on these preliminary findings, Van Gelder et al. (2017) used immersive VR with undergraduate students to examine whether they responded in predictable ways at the subjective, physiological, and behavioral levels to the virtual burglaries they committed, as well as to examine whether individual dispositions (e.g., sensation seeking and self-control) influenced their burglary behavior. In line with expectations, participants reacted subjectively to the burglary event by reporting substantial levels of presence in the virtual environment, as well as physiologically by showing increased heart rates during the burglary. In terms of behavior, a higher risk of apprehension resulted in fewer items being stolen and in a shorter burglary.

3 | CURRENT STUDY AND HYPOTHESES

Nee et al. (2015) and Van Gelder et al. (2017) were primarily concerned with testing the functionality of virtual environments for the study of burglary and established the feasibility of the VR method for crime research. In these studies, however, scholars relied on very small (Nee et al., 2015) or student samples (Van Gelder et al., 2017) and used a restricted virtual environment consisting of a single house that could be burgled. In our current study, we extend this previous work in a variety of ways. We are the first to apply the expertise paradigm to criminal behavior, and to test it among a substantial sample of experienced burglars, as well as to compare their behavior with the behavior of two relevant comparison groups, offenders with no burglary experience (henceforth “other offenders”) and nonoffending community participants (henceforth “nonoffenders”). Expertise theory predicts that burglars show a distinct set of skills that distinguishes them from both other offenders and nonoffenders. Use of this quasi-experimental design, in which the naturally occurring characteristic is accrued experience with committing burglaries, allows for determining whether any expertise demonstrated in burglars is common to offenders in general, or specific to this group. Furthermore, whereas earlier VR work was focused exclusively on burglar behavior *within* houses, the present study also involves neighborhood scouting prior to the actual burglary event and target choice.

We specified the following hypotheses. With respect to scoping the environment and target selection, in comparison with both other groups, we expect burglars to make a more efficient assessment of the neighborhood, either by spending less time before selecting a target or by covering more distance in the same time as others (hypothesis 1); that burglars are more likely to target end-of-terrace properties because of greater ease of entry and exit (hypothesis 2); and that burglars are more likely to enter at the rear of the property as a result of lower visibility and greater scoping opportunities (hypothesis 3). Support for these predictions would be consistent with the early processing aspects of the expertise paradigm: The superior preconscious scanning of the criminogenic environment, and the

---

[1] It is noteworthy that these findings are in contrast to Gottfredson and Hirschi’s (1990) claims: Although students may be assumed to be both more intelligent and to have higher levels of self-control, they were less effective in committing crime than were the burglars who possessed domain-specific expertise.

heightened selective recognition and processing of crime-related cues in the environment that signify the choosing of a potentially lucrative target, based on repeated prior learning and honing of skills in burglary-related situations.

With respect to undertaking the burglary once inside the property, in comparison with control groups, we predict that burglars will undertake a more efficient burglary manifested in the time and/or distance spent in the high-value areas of the house (usually the second floor where most bedrooms are located, hypothesis 4); and that burglars will be more discriminate in what they steal, demonstrating heightened awareness of items with greater value on the illegal market, as well as those that could be stolen with more ease (hypothesis 5). These latter hypotheses are more closely linked to enactment aspects of the expertise paradigm, and are associated with the activation of rich schemas and heuristics about how to enter the target and undertake the burglary, thus, underpinning enhanced performance.

4 | METHOD

4.1 | Participants

In total, 186 respondents (M_{age} = 36.23, standard deviation [SD] = 10.79) participated in the study. Category B and C prisons were purposely targeted for the recruitment of the offender samples as these are typically where those sentenced for burglary are held. Repeat residential burglars[2] in the United Kingdom are typically sentenced to custody and receive sentences of on average 2 years, of which half is served in custody and half is served on license in the community (Sentencing Council, 2011). Thus, participants had not been off the streets for a substantial length of time, which may have adversely affected skills and knowledge about crime. Given the established socioeconomic disadvantage associated with offending populations and our desire to use a comparable nonoffender control group to strengthen the validity of the findings, we focused recruitment for the nonoffender sample on job centers for the unemployed and community centers with food banks.

The results of a power analysis indicated that 50 participants per condition was sufficient to have satisfactory power (.995) and a large effect size ($\eta_p^2 = .138$). We deliberately oversampled to ensure the inclusion of at least 50 experienced burglars (as level of experience was established during data collection) and enough participants in the other samples to enable matching on several relevant variables. The findings from previous research (e.g., Bennett & Wright, 1984; Nee & Meenaghan, 2006; Wright & Decker, 1994) have revealed the use of official offense history to be problematic in identifying experienced burglars as many of the latter do not have extensive convictions for burglary and that snowballing from a small number of competent burglars, prison officers, and other offenders in prison is more efficient. As a result, convictions for burglary were not used as the primary criterion to assess levels of experience. The latter was done through self-report during the interview that took place *after* the experiment had been undertaken (so as not to prime participants' behavior).[3] The fact that prison volunteers knew that we were recruiting both those with and without burglary experience to test the VE helped to assuage any incentive to mislead the researchers about their burglary experience.

---

[2] In the United Kingdom, less prolific burglars receive community sentences.

[3] Nevertheless, despite prison staff constraints, we were able to access offense records for 20 of the 56 in our expert group as an additional check. Eighteen of these had between 1 and 18 convictions for burglary (M = 1, SD = *0.5*); two had none. Of the remaining 36, 21 self-reported burglary convictions that could not be checked and 15 reported none. Thus, 39 of the whole sample of burglars had convictions and 17 did not, supporting findings from previous research. All self-reported considerable experience of doing burglaries, as well as spontaneous verbalizations indicating knowledge about the crime during and after the mock burglary.

Identification of those falling into the “expert burglar” category was achieved in several ways. Self-declared levels of burglary experience were used as the initial criterion for inclusion. Most participants who identified themselves as burglars ($n = 41$) and who were later categorized as “expert” by the researchers did not give a numerical estimate of crimes done, but they said they had done numerous, regular burglaries across their lifetimes; four said they had done at least 10 in the last year at liberty and numerous, unquantifiable burglaries before that; four estimated between 20 and 50 in total; three estimated several hundred; and finally four estimated two per week for ∼10 years. In addition, the three researchers who conducted the study quickly became aware as a result of the spontaneous verbalizations during the “burglary” and the extensive knowledge some prisoners displayed in the postexperiment interviews (commensurate with the skills and knowledge consistently identified in diverse samples examining decision making in burglars: Clare, 2011; Cromwell et al., 1991; Nee & Taylor, 2000; Wright & Decker, 1994) which participants should fall into the “expert” category. So to establish beyond doubt that the participant was an expert burglar, two of the following criteria had to be satisfied: conviction(s) for burglary; self-reported burglary experience; quality and quantity of knowledge about burglary during spontaneous verbalizations during the virtual burglary; and quality and quantity of knowledge about burglary in the postburglary interview. Finally, the research team included only participants on whom all three members agreed. The expert burglars group had spent 6.9 (SD = 2.7) months in prison on average at the time of data collection compared with 7.1 (SD = 3.4) months in the “other offenders” group, which was not statistically different, $t(102) = .259$, $p = .79$. Having categorized our burglars using their convictions and verbalizations that matched indications in previous interview research, our aim was now to see whether their *reenacted behavior* in the VE bore out their statements and made them distinguishable from the other groups as a function of this self-reported expertise.

4.1.1 | Sample attrition

We excluded many of the original 186 participants for one or more of the following reasons. First, we excluded several offender participants either because they had only done commercial burglary ($n = 4$) or had undertaken only one or two burglaries ever in their lifetimes ($n = 6$). These neither fitted the experienced residential burglar group nor the “no burglary experience” group, but their limited experience may have affected how they undertook the simulated burglary. Second, during data screening, box plots and Z scores indicated that three participants (two burglars and one other offender) were outliers on half of the 16 dependent variables ($Z > 2.00$), so these three were excluded from analysis. Furthermore, four burglars had to be excluded from the analyses as a result of software failure during data collection. Finally, of the original 63 nonoffenders recruited, 9 were excluded because they could not be matched with the age range of the expert burglar group. These exclusions resulted in a final sample of 161 participants (56 burglars, 50 other offenders, and 55 nonoffenders).

4.1.2 | Sample offense specialization

Fifty-one out of 56 experienced burglars spoke about other crimes in which they were involved. In line with the research on specialization, only three of these said they exclusively did burglaries. Half ($n = 26$) said they did a range of acquisitive crimes including theft, fraud, commercial burglary, and drug offenses. One third ($n = 18$) described a mixture of acquisitive and low-level violent crime, with a further four mixing burglary with robbery. Of the 32 in the “other offender” group who answered this question, half had histories of violent crime with another 40 percent reporting a mixture of robbery, assault, and some acquisitive crime. The remainder did a wide mixture of mostly acquisitive crime such as theft, car crime, shoplifting, fraud, drug dealing, blackmail, and driving while under the influence. In sum, only 13 of our “other offenders” reported having repeated experience in any type of acquisitive

TABLE 1 Background characteristics and matching analysis for burglars, other offenders, and nonoffenders[a]

Characteristics	Burglar	Other Offender	Nonoffender	*p*
Age *M* (SD) ($n = 161$)	37.5 (8.3)	37.9 (10)	33.9 (10.8)	$F = 2.72$, $p =$ n.s.
Ethnicity ($n = 156$)				Fisher's exact test = 12.93, $p =$ n.s.
White British, Irish, EU	40 (75%)	39 (81%)	46 (84%)	
Black British	5 (9%)	3 (6%)	6 (11%)	
Mixed British	4 (8%)	1 (2%)	3 (5%)	
Black Caribbean	4 (8%)	5 (11%)	0 (0%)	
Total *N*	53	48	55	
Average annual income (£) ($n = 156$)	19,627	23,287	20,198	$F = 0.32$, $p =$ n.s.
Occupation ($n = 160$)				Fisher's exact test = 13.27, $p =$ n.s.
Professional	8 (15%)	6 (12%)	6 (11%)	
Technical, admin. and skilled trades	14 (25%)	16 (32%)	25(45%)	
Caring, sales, machine operatives	10 (18%)	12 (24%)	11 (20%)	
Unskilled	5 (9%)	3 (6%)	2 (4%)	
Unemployed, signed off sick	18 (33%)	13 (26%)	11 (20%)	
Total *N*	55	50	55	
Education ($n = 160$)				Fisher's exact test = 21.20, $p = .001$
No qualifications	12 (22%)	10 (20%)	0 (0%)	
GCSEs[b] or equivalent	28 (51%)	25 (50%)	29 (53%)	
Advanced levels[c] or equivalent	11 (20%)	10 (20%)	16 (29%)	
Bachelor's degree	4 (7%)	3 (6%)	8 (15%)	
Master's degree	0 (0%)	2 (4%)	2 (3%)	
Total *N*	55	50	55	

[a] As more than 25% of the cells had counts of less than 5 for the chi-squared tests, we report Fisher's exact test to avoid type II errors.

[b] These are basic statutory exams, which are usually done at age 16 in the United Kingdom.

[c] These are more specialist exams as preparation for higher level education, usually taken at age 18.

crime (without burglary), with violent crime being much more strongly reflected, whereas more than 80 percent of our burglar sample focused on acquisitive crime or burglary exclusively.

4.1.3 | Matching

In line with the design of other experimental research in this domain (Logie et al., 1992; Wright et al., 1995), once the expert burglar sample had been agreed on, the researchers ensured that the remaining two groups did not significantly differ on several key sociodemographic variables. Specifically, a series of analyses of variance (ANOVAs) and chi-square tests were performed on the three prospective groups until the groups did not significantly differ on the variables. Table 1 indicates the average or most typical (modal) category for the matching variables (age, ethnicity, education, income [legitimate income when at liberty for prisoners], and type of job [when at liberty for prisoners]) for the three groups. As can be seen, no differences emerged except for education. The average age for burglars and other offenders was 38 and 34 for nonoffenders. Three quarters of burglars were White British, Irish, or from the European Union, with less than 10 percent falling each into Black British, Black Caribbean, or mixed ethnicity categories (with similar numbers in the comparison groups). Average (legitimate) income was slightly more than £19.5K. In terms of occupation, the largest category of burglars was unemployed when at liberty (33 percent), although a further 25 percent fell into the technical, administrative, and skilled trades category, with the other groups matched on this pattern. Fewer than 10 percent of any group had unskilled jobs. Initially, offenders differed significantly on highest level of education (Fisher's exact test = 21.20, $p = .001$) with 12 burglars and 10 other offenders having no qualifications at all.[4] Aside from the 22 offenders with no qualifications, there was no significant difference between the rest of the three groups on highest level of education. The most common level of academic attainment (with all three groups greater than 50 percent) was General Certificate of Secondary Education exams, which are the exams one leaves school with in the United Kingdom at age 16.

4.2 | Materials

The virtual environment (VE) was developed with the Unity Pro 4.2[5] engine and consisted of five terraced properties that could be entered through the front door, the rear door, rear upstairs window, and their surrounding environment (figure 1). It was designed to reflect a typical residential neighborhood and property type to be targeted by most residential burglars. A similar, less advanced neighborhood was used in a study by Van Gelder et al. (2017; which aimed in part to test the functionality of the VE with a sample of students).

For reasons of experimental control, the interior of each house was kept nearly identical. On the outside, type and color of curtains and blinds were varied as was the extent to which these were open or closed. Other variations to improve realism included a burglar alarm on the far end-of-terrace house and a bicycle at the front door, whereas the near end-of-terrace house had a car parked in front of it. The rear of the properties could be accessed via an alleyway at the back of the row of houses, through a gate, and into the back garden and had similar variations on the exterior (figure 2).

The internal layout (figure 3) of the properties consisted of the first (ground) floor (kitchen, living room, bathroom, and hallway), second floor (hallway, master bedroom, bathroom, study, nursery, and broom closet), and third (attic) floor (games room and teenage boy's bedroom). Household items were distributed identically throughout each house, including both valuable items such as televisions, laptops, tablets, mobile phones, cash, jewelry, and passports; and other items such as food, books, kitchenware, and picture frames. Nearly all of these could be "stolen" by clicking on them. Some items were placed in clear sight, whereas others were hidden (e.g., a wallet in a jacket pocket, a tablet in a backpack, or a jewelry box in a filing cabinet). Drawers, cupboards, and doors could be opened by clicking on them.

The VE was presented on a laptop computer and could be freely navigated using a game controller or mouse. Stereo headphones were used to add immersive audio, which consisted of typical environmental sounds such as birds singing, cars driving past, aeroplanes overhead, doors shutting, and footsteps. The VR system recorded participant movement, items stolen (weight, volume, and value), and time and distance spent in each part of the environment (e.g., floors of the house). A digital audio recorder was used to record verbal responses to interview questions, as well as the vocalizations of participants as they moved around the VE. Participants were encouraged to "think aloud" as they completed the burglary.

---

[4] As there was no difference among the three groups on occupation and legitimate income while outside prison, this difference in education is likely to signify lack of engagement on the part of the offender groups. As a check of robustness for our key findings, we reran the analyses with offenders with no qualifications excluded with no overall change to the findings. A summary of this analysis can be found in the appendix at the end of the article.

[5] Researchers interested in replicating this study or otherwise using our VE for research purposes can contact the first author.

FIGURE 1 Images of the terrace of houses in the virtual neighborhood plus interior

4.2.1 | Survey and interview

Background variables (noted earlier) were recorded through self-report near the start of the data collection session after informed consent. Gaming experience was coded on a scale from 0 to 20 hours a week. Most variables were coded directly from their raw state, but ethnicity and occupational skill level (which was determined via occupation) were established post hoc using statutory classifications.

Presence, which denotes the subjective feeling of being in the VE and immersion in the task, was measured using the presence scale by Witmer and Singer (1998), which consists of 11 items using 7-point scales measuring from complete immersion to none at all.

Level of experience with burglary and other crimes was measured postexperiment using a semistructured interview protocol. The protocol also measured how participants experienced conducting the virtual burglary, including their sense of comfort/discomfort while reenacting the crime and whether they felt the exercise encouraged them to commit crime, and how they would improve the VE. In addition to the survey, experiment, and questionnaires, participants also verbalized spontaneously during the reenactment and during the postexperiment interview about their experience of the VE and about undertaking the mock burglary and these verbalizations were transcribed. We have added some of these quotes in the Results section to illustrate qualitatively the salient findings about expertise in burglars.

FIGURE 2 Images of the rear of the terrace of houses in the virtual neighborhood

4.3 | Procedure

Once ethical and governmental approval for the study was obtained, access to the prisoner population was negotiated through the governor of each participating prison. Advertisements were displayed in prison wings, and information sheets were distributed to wing offices. The researchers also briefed prison staff and demonstrated the simulation to officers and “trusted orderlies” (prisoners) who helped identify potential recruits. Volunteer participants were invited to meet with one of the researchers. After giving participants the opportunity to ask questions, they were read the consent form to sign, assigned a participant number, and assured that once they and the researcher parted company, their data would be completely anonymous. Consent forms were stored separately from mock burglary data. Note that all information was read aloud to participants and questionnaires were completed with the assistance of a researcher to side step any potential literacy issues without embarrassment.

Once the demographics survey was completed, instructions for undertaking the virtual burglary were provided. The instructions included a picture of the first image participants would see on the screen once in the VE, plus details of how to navigate and interact with the environment using the mouse/gamepad and how to burgle the target (e.g., how to open doors, pick up and drop items, and crouch). Participants were instructed to approach the exercise as if it were a real burglary, to scope the neighborhood for as long as they needed to choose a house, and then to take as long as they felt

FIGURE 3 Floor plan and interiors of floors 1, 2, and 3

they would do in real life to undertake the burglary but to bear in mind the risk of being disturbed, or that the police might arrive. Having been asked whether they wished to clarify anything, a crib sheet of instructions was placed in front of them, they were given the headphones, and the simulation was started. The data collection episode from this point to the end of the post-"burglary" interview was audio-recorded with the permission of the participant.

Participant movement slowed down as a function of the number of items picked up, to the point where no more items could be picked up. The hallway functioned as a "drop zone," which meant that any objects in the hallway were registered as successfully stolen once participants left the house. After dropping items in the drop zone, participant movement returned to the initial "normal" setting. There was no limit to the number of items that participants could steal, and participants could be in the house for as long as they felt was needed. Once participants had entered a house, they could not leave and enter another house to burgle. The burglary ended when participants exited the house and pressed "Q" on the keyboard.

Each participant then completed the presence questionnaire followed by a semistructured interview regarding his or her experiences of completing the virtual burglary. During this conversation, it was ascertained whether the participant identified him- or herself as an experienced burglar, what convictions he or she had, and whether the person committed a mixture of crimes. For those who had been involved in burglary before, the questionnaire inquired in further detail about their prior burglary experience, as well as about the similarities between the simulation and real-life burglaries.

As we were aiming to match the nonoffender sample with the burglars socioeconomically, advertisements for the latter sample were displayed in various community centers in working class areas and less affluent areas of the city of Portsmouth, including community centers with food banks and the local job center where citizens register for unemployment benefit. These advertisements described the research and what would be involved in participation. Male individuals interested in taking part were invited to a research lab at the University of Portsmouth, Department of Psychology, where they were met by a member of the research team. The procedure was then identical to that for (nonburglar) offenders (questions about burglary experience were omitted). These participants were additionally asked to complete an anonymous self-reported offending behavior questionnaire, which was posted into a ballot box with their other demographics. They were offered a £5 supermarket voucher for taking part.

Finally, all participants were debriefed, given the opportunity to ask questions, and provided with information of relevant bodies should they feel they needed to talk further about the study or discuss any potential feelings that their participation had elicited (for example, the prisoners were provided with information on the "listener system"). The entire session took approximately 1 hour.

4.4 | Analysis

To examine differences in expertise between the three conditions, we applied a range of inferential statistics including multivariate analysis of variance (MANOVA), *t* tests, and chi-squared tests. Significant main effects were tested using univariate methods. Only two points in the data were missing, both regarding the presence questionnaire data, and these were missing completely at random (see Little & Rubin, 2002). As a result of the limited number of missing data points, it was considered acceptable to replace them using mean substitution (Graham, 2009). The mean and standard deviation of the variables did not alter with and without these missing data replaced; hence, to retain the sample size, variables with the missing data replaced were used in all future analyses. No significant differences emerged between levels of gaming experience in the three groups ($\chi^2 = 1.88$, $p = .757$). It was used, however, as a covariate in the relevant analyses to control for its effect on performance during the burglary.

We conducted a single MANOVA on all dependent variables: time (total time in the environment; total time before entering house; total time inside house; total time on each of the three floors in the house); distance traveled (total distance in whole environment; total distance before entering target; total distance after entering target; total distance on each of the three floors in the house); and items stolen (total number, weight, volume, and value). The MANOVA indicated a significant multivariate main effect for Expertise, Wilks $\lambda = .65$, $F(32, 286) = 2.12$, $p = .001$, $\eta p^2 = .19$. Univariate analyses will be reported to examine each hypothesis separately.

5 | RESULTS

5.1 | Scoping the environment and target selection

In hypothesis 1, we stated that burglars would make more efficient assessments of the neighborhood, by spending less time before selecting a target, and/or by covering more distance in the same time as others. A significant difference was found among the three groups in the total distance traveled before entering the target, $F(2, 158) = 3.57$, $p = .03$ $\eta_p{}^2 = .43$. Pairwise comparisons indicated that burglars scoped a significantly greater distance (in meters) around the neighborhood ($M = 114.75$, SD = 65.01) than did nonoffenders ($M = 80.37$, SD = 59.91), $p = .01$. Burglars also scoped a greater distance than did other offenders ($M = 94.54$, SD = 79.95), although this was not statistically significant ($p = .13$). No difference emerged either between other offenders and nonoffenders in distance covered ($p = .29$). Importantly, in support of hypothesis 1, the extra distance was covered by burglars in the same amount of time as the other groups, $F(2, 158) = .83$, $p = .44$, $\eta_p{}^2 = .01$. The following quote from a burglar indicates the kinds of cues being processed while scanning the environment:

> *You look at what people live in, what people are driving, and you can work out what people may own, may have, what money they might have, what jewelry they might have, whatever it might be, you can pretty much picture it in your head what could be inside a building, inside a garage, inside a cupboard. (Burglar #76)*

In hypothesis 2, we predicted that burglars were more likely to target end-of-terrace properties as a result of greater ease of entry and exit. In support of this prediction, the results of a chi-square test indicated a significant relationship between expertise and target selection with more burglars selecting the end-of-terrace houses (73 percent, $n = 41$) than either other offenders (44 percent, $n = 22$) or nonoffenders (49 percent, $n = 27$), $\chi 2$ (2, $N = 161$) = 10.72, $p = .01$. In hypothesis 3, we predicted that burglars would more likely enter at the rear of the property as a result of lower visibility and greater scoping opportunities. The results of a chi-square test again indicated a significant relationship between the variables with more burglars (52 percent, $n = 29$) than either other offenders (38 percent, $n = 19$) or nonoffenders (31 percent, $n = 17$) entering at the rear of the property, $\chi 2$ (2, $N = 161$) = 5.19, $p = .04$, supporting our prediction.

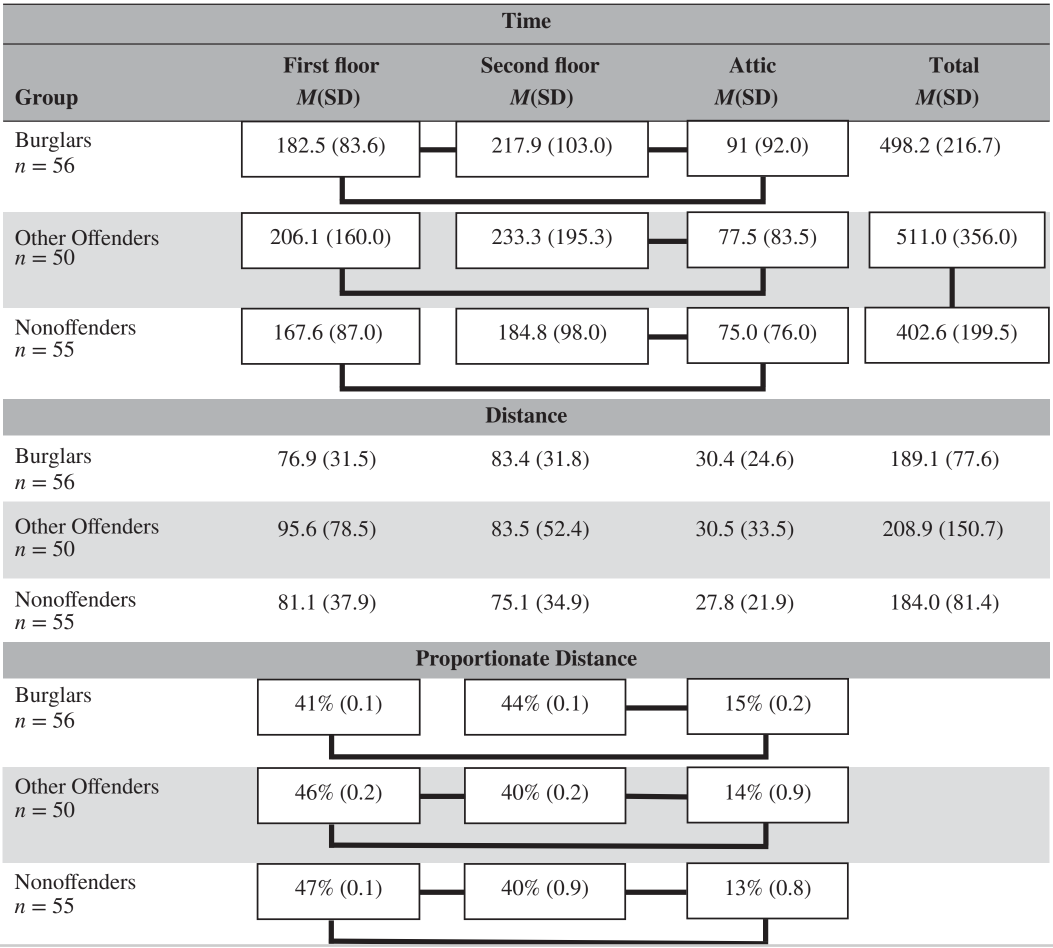
5.2 | Undertaking the burglary once inside the property

In hypothesis 4, we predicted that burglars would undertake a more efficient burglary compared with both other groups, manifested in the time and/or distance spent in high-value areas of the house (the second floor). Differences emerged in relation to the three groups, although in a more complex way than predicted.

5.2.1 | Time spent in house

Searching the house as a whole indicated only one difference between groups that approached significance, $F(2, 158) = 2.54$, $p = .08$, $\eta_p{}^2 = .03$. Pairwise comparisons revealed that nonoffenders took

TABLE 2 Means and standard deviations of time (s), distance (m), and proportionate distance (%) on each floor



Group	First floor *M*(SD)	Second floor *M*(SD)	Attic *M*(SD)	Total *M*(SD)
Time				
Burglars $n = 56$	182.5 (83.6)	217.9 (103.0)	91 (92.0)	498.2 (216.7)
Other Offenders $n = 50$	206.1 (160.0)	233.3 (195.3)	77.5 (83.5)	511.0 (356.0)
Nonoffenders $n = 55$	167.6 (87.0)	184.8 (98.0)	75.0 (76.0)	402.6 (199.5)
Distance				
Burglars $n = 56$	76.9 (31.5)	83.4 (31.8)	30.4 (24.6)	189.1 (77.6)
Other Offenders $n = 50$	95.6 (78.5)	83.5 (52.4)	30.5 (33.5)	208.9 (150.7)
Nonoffenders $n = 55$	81.1 (37.9)	75.1 (34.9)	27.8 (21.9)	184.0 (81.4)
Proportionate Distance				
Burglars $n = 56$	41% (0.1)	44% (0.1)	15% (0.2)	
Other Offenders $n = 50$	46% (0.2)	40% (0.2)	14% (0.9)	
Nonoffenders $n = 55$	47% (0.1)	40% (0.9)	13% (0.8)	

Note: ☐━☐ Indicates comparison significantly differs at $p < .05$ (two-tailed).

significantly less time to search the house than did other offenders ($p = .04$). Burglars took on average 1.5 minutes longer than nonoffenders (table 2). This average of ~9 minutes for burglars compares favorably with Nee and Meenaghan (2006) whose burglars reported less than 15 minutes as typical and with security websites indicating 8–12 minutes (Safewise Report, 2017). There was no significant difference between the two offender groups ($p = 1.00$). Consequently, no significant differences were found in relation to time spent on each floor (all p's > .22).

The results of analyses within groups on time spent on each floor as a proportion of total time, however, highlighted some interesting differences. Burglars spent significantly more time on the most lucrative second floor (45 percent, as opposed to 39 percent [first floor] and 16 percent [attic floor]), $F(2, 48) = 61.91$, $p < .001$, $\eta_p^2 = .53$. Table 2 indicates that burglars spent a significantly different amount of time on each floor. For the other groups, however, although an overall significant difference was seen (other offenders: $F(2, 48) = 34.72$, $p < .001$, $\eta_p^2 = .41$; nonoffenders: $F(2, 53) = 54.24$, $p < .001$, $\eta_p^2 = .50$), this was only in relation to the attic floor and other floors, with no difference between the first and second floors, indicating less knowledge about the second floor.

TABLE 3 Number, value, weight, and volume of items chosen during the virtual burglary by each group

Group	Number *M* (SD)	Value (€) *M* (SD)	Weight (g) *M* (SD)	Volume (L) *M* (SD)
Burglars *n* = 56	15 (7.4)	2,571 (1260)	48.2 (3.0)	258.2 (196.0)
Other Offenders *n* = 50	17 (13.2)	2,597 (1363)	57.0 (4.0)	321.0 (227.4)
Nonoffenders *n* = 55	20 (15.3)	2,927 (1087)	66.3 (37.0)	351.4 (188.9)

Note: ☐━☐ Indicates comparison significantly differs at $p < .05$ (two-tailed).

5.2.2 | Distance covered in the house

Another interesting, although complex, picture emerged in relation to distance covered on the different floors of the house (table 2). Again, no significant differences emerged *between* groups regarding the total distance in the whole house, $F(2, 158) = .78$, $p = .46$, $\eta_p{}^2 = .01$, or distances traveled on any floor (all p's > .16). Distance traveled on each floor, however, as a proportion of total distance traveled within each group was again enlightening.

Significant main effects were seen for all three groups (burglars: $F(2, 110) = 96.77$, $p < .001$, $\eta_p{}^2 = .64$; other offenders: $F(2, 98) = 51.15$, $p < .001$, $\eta_p{}^2 = .51$; nonoffenders: $F(2, 108) = 105.49$, $p < .001$, $\eta_p{}^2 = .66$), but for burglars, pairwise comparisons indicated that there was no significant difference in the distance traveled between the first and the second floor (see the Proportionate Distance section of table 2). That is, burglars were traveling almost equal distances on the two floors respectively. For the other groups, there were significant differences between distance traveled proportionately on all three floors, with most distance covered proportionately on the first floor, followed by the second floor, followed by the attic. When we reflect on the findings regarding timing, we see that all participants traveled a limited distance in the smaller attic space.

To summarize, in comparison with both other groups, burglars preferred to spend most of their time proportionately on the most lucrative floor, without traveling any greater distance on it and traveled the least distance on the first floor in contrast to other groups. Taken together, these findings lend support to our prediction that burglars undertook a more efficient burglary (hypothesis 4). Burglar #110, in contrast to members of the comparison groups, demonstrates his motivation to navigate to the most lucrative areas of the house as quickly as possible and that upstairs always offers richer rewards, in the following quote:

> *Yeah, I'd use the back gate, have a scout around for witnesses. … Always go to the top [of the house] first because you've got jewelry boxes, coz I've got a big telly, but a jewelry box can have more money than an entire house. (Burglar #110)*

5.3 | Items stolen

In hypothesis 5, we predicted that burglars would be more discriminate in the items they stole. As can be seen in table 3, aside from value, the means are all in the predicted directions. Significant differences were found for weight, $F(2, 158) = 3.50$, $p = .03$, $\eta_p{}^2 = .04$, and volume, $F(2, 158) = 3.01$, $p = .05$, $\eta_p{}^2 = .04$, of items stolen with pairwise comparisons indicating significant differences between burglars and nonoffenders for both factors (all p's < .03). The number of items stolen also approached significance, $F(2, 158) = 2.30$, $p = .10$, $\eta_p{}^2 = .03$, with a significant difference in pairwise comparisons between burglars and nonoffenders ($p = .03$). Burglars chose fewer, lighter, and smaller items,

TABLE 4 Average preferences for each item category for each participant group

Group	Large high-value items *M* (SD)	Small high-value items *M* (SD)	Mid-value items *M* (SD)	Low-value items *M* (SD)
Burglars $n = 56$	5.5 (2.2)	5.0 (2.4)	2.6 (2.4)	3.4 (2.2)
Other Offenders $n = 50$	5.9 (2.2)	4.8 (2.6)	3.6 (2.5)	6.6 (8.6)
Nonoffenders $n = 55$	6.0 (2.6)	4.5 (2.4)	3.8 (2.2)	7.7 (13.5)

Note: ☐━☐ Indicates comparison significantly differs at $p < .05$ (two-tailed).

especially in comparison with nonoffenders. Other offenders were not significantly different from either comparison group (all p's $> .35$).

In contrast to expectations, there was no significant difference in relation to the total value of the objects taken, $F(2, 158) = 1.40$, $p = .25$, $\eta_p^2 = .01$, with both other offenders and nonoffenders achieving a slightly more valuable "haul" than burglars. The absence of differences, however, was explained in relation to the type of items stolen. Up to 159 items in the house could be stolen. The range of items stolen for burglars was 2–37, for other offenders was 2–65, and for nonoffenders was 3–116 items, highlighting a difference in levels of discrimination between the groups. Items that could be stolen were grouped into high-value (passport, jewelry), mid-value (printer, DVD player), and low-value (food, books), and high-value items were further grouped into small (jewelry, passport) and large high-value (TV, PC) items based on findings from an earlier pilot study in which burglars seemed to prefer smaller items (Nee et al., 2015). Table 4 provides a summary of the means for each group of items.

As can be seen in table 4, trends emerged in relation to different types of items. Burglars took fewer low-value items than did nonoffenders, and this approached significance, $F(2, 124) = 2.48$, $p = .09$, $\eta_p^2 = .04$, with pairwise comparisons indicating a significant difference between burglars and nonoffenders ($p = .03$). Similarly, they were less attracted to mid-value, bulkier goods, $F(2, 124) = 2.96$, $p = .06$, $\eta_p^2 = .05$, than were nonoffenders ($p = .02$). In contrast, the data in table 4 indicate that large valuable items were favored by nonoffenders though this difference was not statistically significant, $F(2, 124) = 0.50$, $p = .60$, $\eta_p^2 = .01$. Furthermore, the data in table 4 lend support to the idea that burglars preferred small, valuable goods, but when all 12 of these items were examined together, the difference was not statistically significant, $F(2, 124) = 0.38$, $p = .69$, $\eta_p^2 = .01$. The data, however, showed a clear difference in seven items, and when these were looked at separately, the difference approached statistical significance, $F(2, 151) = 2.55$, $p = .08$, $\eta_p^2 = .04$, with pairwise comparisons identifying that the difference was between burglars and nonoffenders ($p = .03$). The starkest difference between groups was in three small items of substantially highest value in the house (a ring, passport, and necklace that were hidden in a jewelry box in a filing cabinet in the study). Considerably more burglars found these items (range $n = 14$–15) than did either other offenders (range $n = 6$–8) or nonoffenders ($n = 6$). Most popular items for burglars were generally harder to find. Alongside those in the filing cabinet, these included a wallet and an Apple® iPad2™ in the dining area (unlike other groups, burglars were more interested in this than in the basic model iPad™ upstairs), and a camera and a ladies' wallet in the main bedroom.

Thus, the reenacted burglary furnished us with much richer and more complex data regarding item preference in burglars than was previously possible, but that supports the idea that burglars would be more discriminate in the items they chose (hypothesis 5). The following quote clearly indicates heightened knowledge and an ability to prioritize and attend to items that are more lucrative and more realistic to steal:

> *The first thing a burglar does is go upstairs and look for gold. You wanna look for small items, expensive items. Especially if you can put them in your pocket so you're walking out the same way you walked in. You'd rather not take a TV if you can possibly help it. I went straight upstairs first. As I'm walking up I'm quickly clocking things, thinking I'm having that on the way down. (Burglar #118)*

5.4 | Further analysis in relation to presence and well-being

Presence was high for all three groups (burglars: $M = 52.25$, SD = 8.68; other offenders: $M = 52.04$, SD = 6.52; nonoffenders: $M = 55.41$, SD = 7.16) on a scale in which any score greater than 44 indicated high presence (possible range 11–77).

All participants were asked how comfortable they felt (meaning well-being rather than physical comfort) on a scale of 1–10 while doing the burglary (1 = *completely comfortable*, 10 = *completely uncomfortable*). A significant difference was found between groups ($F(2, 158) = 10.78, p < .001, \eta_p{}^2 = .13$). Prisoners reported feeling significantly more uncomfortable (burglars: $M = 5.22$, SD = 3.07; other offenders: $M = 4.65$, SD = 3.56) than did nonoffenders ($M = 2.53$, SD = 2.39), $p < .001$. This perception of mild discomfort importantly indicates that the simulation effectively reinstated the context of the crime for the offenders, whereas it was just an innocuous task for the nonoffenders. We finish the Results section with a quote that at once reflects distinctive knowledge about the importance of not being conspicuous in the environment while choosing and departing from the target, and the deepening of automaticity once inside the target, to get the job done with minimum risk and maximum gain:

> *The idea is you don't want to look like a burglar, I'm not in a black mask with a stripy top and a swag bag, the idea is to walk in unnoticed and walk out. I could be looking out for police and that but once I'm in, I'm zoned into what I'm doing and I cross that bridge when I come to it. (Burglar #23)*

6 | DISCUSSION

For this study, we recruited experienced burglars into a virtual reality task designed to tap into their offense-related skills and decision making. In doing so, we have attempted to demonstrate burglars' enhanced expertise and to deepen our understanding of the psychological mechanisms involved. Extending previous work in which virtual environments were used (Nee et al., 2015; Van Gelder et al., 2017), our design allowed for us to observe experienced burglars as they undertook the entire burglary episode from evaluating a neighborhood to choosing a target and subsequently burgling it. Therefore, we could get a detailed glimpse at burglars while on the job, disclosing information that was hitherto inaccessible, and demonstrating potential for crime prevention, desistance, and theory development regarding offender expertise and decision making.

To start out with the latter, the empirical evidence for the automatic processing of information and the storage of key knowledge in long-term memory extends our current theoretical understanding of offender decision making in various ways. For one thing, it has been suggested repeatedly that burglars describe their half-aware scanning of the environment as neither planned nor opportunistic but based instead on learned skills that have become second nature (Cromwell et al., 1991; Taylor & Nee, 1988; Wright & Decker, 1994). The expertise paradigm provides an explanation for this description extending rational choice theories by pinpointing what specific types of attentional and appraisal processes are at work in the burglar's mind. In our view, an expertise framework has the conceptual resources to extend rational choice models by identifying the psychological mechanisms involved in the commission of a crime. The rational choice perspective provided a valuable foundation in that the actions and associations between offenders and their environments are described and criminal decisions are constrained by satisficing, limited information, and the use of heuristics. Even though processes that are not necessarily conscious are alluded to (e.g., bounded rationality), the perspective does not venture into the nature of these processes. To build on the foundation of rational choice, the expertise paradigm laid out in the present study can be used to help identify specific types of cognitive mechanisms employed at and around the scene of the crime. In addition, a new understanding is provided as to how particular types of learning, practice, and experience are likely to increase (criminal) expertise.

In a similar vein, besides replicating previous research findings such as architectural and topographical aspects of the chosen target and the method of entry, we have additionally enabled greater insight into the actual performance of the crime, for example, with respect to the well-established feature of higher speed in execution associated with increased practice in the task. Based on previous research findings, we expected burglars to undertake a faster and more lucrative burglary, as well as to use cleaner routes than the other groups once they had entered the house. A somewhat more complex picture emerged, however, that cannot be explained without watching the reenactment of the burglary. Nonoffenders undertook the burglary significantly faster than either offender group, replicating a finding in a recent preliminary study capturing' ex-offenders' actual movements in relation to a real and a simulated house in comparison with students (Nee et al., 2015). An explanation for this can be found in the mainstream expertise literature (Chi, 2006). At the extreme (novice) end of the expertise continuum are "naivettes," individuals characterized by total ignorance of a domain (as opposed to being new to an area or not knowing very much about it—like most novices). We believe the nonoffenders in the current study and the students in Nee et al. (2015) fell into the category of naivettes. In both cases, it was obvious while observing them that they had no previous experience. They moved chaotically from room to room choosing large, visible, obvious objects (large TVs and computers), consequently finishing their burglaries more quickly than the offenders. In the current study this, by default, afforded them a better, but unrealistic financial outcome. The burglars, in contrast, were driven automatically by their script-like knowledge, aiming directly for the lucrative bedrooms and study upstairs, spending the larger part of their time here (but not traveling significantly farther), indicating persistent searching and employing tried and tested skills to uncover the smallest, most lightweight, and valuable items. Thus, in support of the first aim we set out at the beginning of the article, burglars, and likely experienced offenders in general, have distinct and superior knowledge and skill in relation to undertaking the actual crime whether or not their everyday lives are in disarray and they are generally considered "losers" who "on the whole are not very good at what they do" (Hirschi, 1986, p. 118). The study findings reveal the most rigorous evidence to date of the kind of cue recognition, schema activation, and automatic crime enactment redolent of the expertise paradigm and what Nee and Ward (2015) have described as "dysfunctional" expertise in relation to offenders.

Before discussing the broader implications for crime prevention and rehabilitation policy, it is important to revisit the second aim of this study, which was demonstrating that virtual environments can be effectively used to study crime as it unfolds. The overwhelming majority indicated during the interview that it was a worthwhile and valuable research tool. A key, and perhaps at first sight surprising, finding was that all offenders, and burglars especially, felt less comfortable than did nonoffenders undertaking the virtual burglary. None, however, reported it would make them consider undertaking the crime again, which suggests that the virtual environment re-created the context of the crime enough to evoke the cognitions, emotions, and behavior commensurate with a real burglary, allowing for researchers to study it with integrity, while not being so realistic as to distress or excite them too much, or encourage them to reconsider taking up the crime again. On the contrary, verbalizations during and after the exercise indicated they were reflecting as much in a remorseful way as on the anxiety/arousal aspect of the burglary.

In the current study, we also go several steps further than in previous work using VR to study burglary. By using a neighborhood, it represents a significant departure in terms of size, realism, detail, and scale of measurement from the single houses used in prior studies (e.g., Nee et al., 2015; Van Gelder et al., 2017). For example, in both latter studies, limited movement was possible and only one house could be entered, so participants could not scope the neighborhood or choose a target house. This plus the nature of the samples meant that these studies were not designed or equipped to test theory such as the expertise paradigm in a meaningful way. In contrast, by observing the first sizable sample of experienced burglars undertaking the scoping of a neighborhood, selecting a target, and performing a burglary in comparison with other offenders and matched nonoffenders, through the current study, we now have new and meaningful findings about the competence of burglars, as well as a deeper understanding of the automatic, cognitive processes involved. Although our burglar sample is not representative of all burglars in the United Kingdom or beyond (see limitations in a later discussion), given the fact that the present study consistently replicates findings of earlier burglary research spanning several decades, drawing from diverse samples in different contexts around the world, and using a range of diverse methodologies, we have confidence in the generalizability of our results.

The research potential of VR is not limited to the domain of burglary but also extends to other types of crime. For crime theory and research, this innovation could be consequential. Interviewing techniques have been and will continue to be effective and versatile methods in criminological research, but both depend on sound retrieval and on the assumption that the actor has access to and can verbalize reasons for his or her behavior and decisions. We know that the human memory is limited by inferential errors, telescoping forwards, overestimation, and bias about what an individual might have or should have thought and done (Bradburn, Rips, & Shevell, 1987; Ericsson, 2006; Nee, 2010; Tulving, 2002) and that verbalizations about behavior are considered to be the last stage in a sequence of complex cognitive steps (Ericsson, 2003; Ericsson & Simon, 1993). Little can improve the elicitation of nonreactive verbal reports *while completing a task*—in other words, thinking aloud (Ericsson, 2003)—and virtual environments represent a method in which the major memory and environmental flaws in interviewing are minimized. Thus, a new door is opened, which can substantially advance our knowledge of the development of skill and identity in offending. Also, use of interview techniques cannot tap into that part of our mental operations that guide behavior and decision making that play out below the threshold of conscious awareness. As the results of this study, and those of many expertise studies that preceded it, show, the influence of these unconscious processes on decision making and building expertise is ubiquitous. The virtual enactment approach proposed was shown to be an informative way to identify these processes and incorporate established insights from several decades of cognitive psychology research into the development of expertise and can significantly enhance our understanding of criminal decision making.

We see the broader implications of our research approach for policy and practice as twofold. First, as our findings indicate, the ability of VR to gain a more accurate insight into the different stages of the offending process, such as the appraisal of the environment and the commission of the crime, can contribute to developing a more encompassing understanding of how to change that environment to reduce the opportunity for criminal activity. This could, for example, inform crime prevention through environmental design (Ekblom & Hirschfield, 2014; Jeffrey, 1971). In particular, the possibility of adding experimental variation to the virtual environment, while maintaining researcher control in a naturalistic setting with high ecological validity, opens up novel opportunities for testing the effectiveness of various types of security measures. Such research findings could furnish us with more effective and reliable deterrence cues, which can be systematically deployed at each step of the way to deter the potential intruder (for example, an unexpected neighbor, lack of rear access to disrupt schemas at the scouting stage, or unexpected noises or an unusual layout once inside the property).

Moreover, the integration of VR technology with the advent of artificial intelligence (AI) and machine learning in crime prevention could further enhance community and individual safety. Advanced data analytics used in "predictive policing" have already been seen to reduce the opportunities for burglary significantly (Mohler et al., 2015), at least in the short term, outperforming crime analyst and traditional burglary hot-spots prediction of high crime. Data on offender-based scoping behavior would surely enrich these algorithms. Regarding prevention/disruption once an intruder has gained entry, interest in home-security systems using advanced AI technology is currently growing exponentially (RnR Market Research, 2017). One can envisage how systems using facial recognition could stream in data about the known gait, timing, and motivation of potential intruders and activate a range of tailored deterrence cues learned from research such as the present study and future work using VR technology. AI and mathematical modeling in crime prevention can be criticized for not including the human (offender) factor such as individual motivations for the crime (Brantingham, Glässer, Jackson, Kinney, & Vajihollahi, 2008). Agent-based modeling, the aspect of predictive modeling designed to add this feature, has been argued to be too simplistic and using too "rational" a model of offender thought (Malleson, Heppenstall, & See, 2010). Given that offenders and ex-offenders are most often happy to share their knowledge, enjoy the medium of VR, and consequently disclose more using this method (Meenaghan, Nee, van Gelder, Otte, & Vernham, 2018), it stands to reason that our methodology can offer crucial missing pieces to these new technologies as we move forward.

In other pertinent crime prevention research, some questions that can be addressed effectively using VR methodology are those centering on group offending. Evidence suggests around half of all burglaries occur in groups (Carrington, 2009). Although group offending was not the goal of the present study, VR technology does allow for having multiple users at once in a virtual environment and, hence, for the study of burglary with co-offenders. Research may be conducted, for example, to determine whether distinct expertise is associated with particular roles within the group. If such typologies can be identified, this knowledge could be exploited to enhance further a more systematic approach to disrupting opportunities around the crime scene.

Finally, law-abiding citizens are notoriously poor at understanding burglary risk and/or the opportunities for crime they leave inside and outside their homes and around their communities because they lack the schematic knowledge of the burglar. Given the low clearance rate, previous attempts at education of householders to reduce risk and opportunity have perhaps reached a ceiling in effectiveness. By "doing" crime reduction techniques and learning to understand the burglar's perspective in a virtual environment (and then using augmented reality in their own homes), ordinary citizens can be trained to become significantly more aware of burglary risk and subsequently reduce opportunities around their homes and communities.

The second implication of this study for practice regards its potential for offender rehabilitation. A considerable challenge for correctional practitioners working with offenders desisting from crime is to understand more clearly the complex interplay among habitual behavior, cognition, and emotion (arousal, anxiety, reward) and how these change at various points in the decision chain. Much of this is likely to be automatic and only partially conscious (Ericsson & Simon, 1993; Kahneman, 2011; Montero, 2016), and early decisions to undertake the crime may be hours, days, or more before the actual crime. Despite the established empirical underpinning of the habitual and automatic nature of experienced decision making (criminal or otherwise), to date, this crucial issue has been roundly overlooked by offending behavior programs.[6] By acknowledging, understanding, and accepting the well-established human capacities associated with survival and learning in our environments such as preconscious scanning for reward and threat, the development of schemas, and the automaticity of decision making, we can make important advances in the rehabilitation of offenders. Finally, expertise in offenders is unique in the sense that it has a dual normative status: It is both a risk factor for persisting in a criminal career and potentially a protective factor in desisting from it (Nee & Vernham, 2016; Nee & Ward, 2015). The functional aspects of these cognitive and emotional capacities can be elucidated and built on in the rehabilitative setting, affording the desister a greater sense of agency and the motivation that this affords. It assists the offender in reapplying the features of expertise from dysfunctional to functional within various aspects of his or her life (Vernham & Nee, 2016).

Despite our efforts at achieving high levels of validity and generalizability, it is important to discuss the several limitations this study had. First, in regard to the method, it is important to stress that a virtual crime, however realistic, is still not a real crime. Additionally, our virtual neighborhood was simple with only five terraced houses that could be “burgled” and interiors being almost identical to improve experimental control. Despite the fact that curtains and blinds varied in the degree to which they were closed, many burglars noticed that houses were identical inside and commented that this was not realistic. To counter this limitation, with the proof of concept now verified, future studies can have more varied, naturalistic environments. They can also comprise aspects more nuanced to particular cultures to improve crime reduction knowledge by, for instance, including prescription medication and guns in U.S. studies, or architectural considerations reflecting communities across the world.

In regard to the sample, a potential point of contention is that the offenders were imprisoned rather than active burglars. Researchers interviewing active offenders at the scenes of recent crimes have criticized the use of prison-based samples with respect to imprecise recall of behavior and regarding their “failed” status as criminals (Cromwell et al., 1991; Wright & Decker, 1994). As Nee (2010) observed, however, participants are often not in prison for burglary but for other crimes (as with our sample). Furthermore, reviews of findings using both types of recruitment, from diverse samples across the world, indicate remarkable consistency with regard to decision making such as the types of environmental cues used in target selection and behavior once inside the property (Copes & Hochstetler, 2010). As a result of the prolific nature of burglary, today’s active offenders are likely next year’s incarcerated ones (Coupe, 2017; Shover, 1996). Furthermore, as Nee (2010) observed, interviewing participants outside a recently burgled property (Cromwell et al., 1991; Wright & Decker, 1994), remains interviewing, and not reenactment, and is therefore still subject to limitations of memory. These study findings do raise another important potential limitation of our research, however, in that their participants were more obviously active drug users compared with ours.

The issue of addiction is important as a considerable proportion of burglars have substance misuse problems (Clare, 2011; Cromwell et al., 1991; Wright & Decker, 1994) and it is reasonable to suppose that this affects proficiency. That said, we know that it is rare for burglars to be caught at the scene of the crime (Maguire & Bennett, 1982; Shover, 1973; Wright & Decker, 1994). This given, coupled with extremely low clearance rates (13 percent in the United States; Federal Bureau of Investigation, 2009, and 17 percent in England and Wales; Smith, Taylor, & Elkin, 2013), implies that the influence of addiction may not radically affect competence while undertaking the crime. One explanation might be that during consumption, as neuroscientific research findings bear out, substance misuse most acutely affects working memory and impulse control (Lundqvist, 2005; Rogers & Robbins, 2001) but may not adversely affect the ability for long-term memory schemas and scripts to pop out automatically

---

[6] Bar one publication in which some of the concepts in a limited way are outlined with little or no impact on practice (Ross & Hilborn, 2008).

in response to triggers in the environment, allowing for the intoxicated burglar to still carry out a competent burglary.

Our sample is not representative of all residential burglars in the United Kingdom. In being drawn from a broader range of cultures, behaviors, and environments, however, it could be argued that prison-based burglars are more representative of the burglar population as a whole than are the tightly networked snowball samples of active offenders commonly used in ethnographic studies (Bennett & Wright, 1984). The latter reflect burglars typical of the geographical area and culture from which they are drawn only. We took care in allocating our prisoner sample into experienced burglars and other offenders, and we exceeded the sample size that made the statistical power of our outcomes valid and meaningful. In this sense, our findings are at least as valid and generalizable as those from active offenders from the same network, and we would argue even more so, given the exacting methodology we employed.

Conducting research in prisons is challenging, and with greater time and resources, samples could have been cleaner and more stratified. Future research could comprise tighter age ranges and more stratified samples of offenders without burglary experience (perhaps separating violent and acquisitive offenders) or include a correlational methodology to look at associations between increased expertise and/or specialism and more "successful" outcomes. It is undeniable, though, that even with the somewhat diverse range of burglars in this study, we have supported and extended our understanding of expertise in burglars. Overall, the findings generated from using our sample lend support to the notion that most property offenders do a mixture of crimes, but some specialization, at least for periods of time, must occur (DeLisi et al., 2011; Nieuwbeerta et al., 2011); otherwise, this expertise could not have accrued. Our burglars demonstrated greater knowledge and skill on numerous measures than did the other groups.

Further work needs to be done to extend this initial study on the expertise of residential burglars and indeed on other types of crime. That said, we have at once replicated in action what we have learned from decades of verbal reports from interview studies, using methods unmatched in detail and rigor, and we have begun to reveal nuances and depths of insight well beyond the capability of previous approaches. We expect the methodological, theoretical, and policy advances that this approach will facilitate in years to come to be substantial, contributing significant insights into the study of offending behavior that have previously been inaccessible.

ORCID

Claire Nee https://orcid.org/0000-0002-4934-7262

REFERENCES

Armstrong, T. (2008). Are trends in specialization across arrests explained by changes in specialization occurring with age? *Justice Quarterly*, *25*, 201–222. https://doi.org/10.1080/07418820801954654

Bargh, J. (1994). The four horsemen of automaticity: Awareness, efficiency, intention, and control in social cognition. In R. S. Wyer & T. K. Srull (Eds.), *Handbook of social cognition* (2nd ed., pp. 1–40). Hillsdale, NJ: Erlbaum. https://doi.org/10.1007/s00572-005-0022-9

Bargh, J., Gollwitzer, P., Lee-Chai, A., Barndollar, K., & Trötschel, R. (2001). The automated will: Nonconscious activation and pursuit of behavioral goals. *Journal of Personality and Social Psychology*, *81*, 1014–1027. https://doi.org/10.1037/0022-3514.81.6.1014.

Bechara, A., & Damasio, A. (2005). The somatic marker hypothesis: A neural theory of economic decision. *Games and Economic Behavior*, *52*, 336–372. https://doi.org/10.1016/j.geb.2004.06.010.

Bennett, T., & Wright, R. (1984). *Burglars on burglary : Prevention and the offender*. Aldershot, England: Gower.

Bernasco, W., & Luykx, F. (2003). Effects of attractiveness, opportunity and accessibility to burglars on residential burglary rates of urban neighborhoods. *Criminology*, *41*, 981–1002. https://doi.org/10.1111/j.1745-9125.2003.tb01011.x.

Bernasco, W., & Nieuwbeerta, P. (2005). How do residential burglars select target areas? A new approach to the analysis of criminal location choice. *British Journal of Criminology*, *45*(3), 296–315 https://doi.org/10.1093/bjc/azh070

Bradburn, N., Rips, L., & Shevell, S. (1987). Answering autobiographical questions: The impact of memory and inference on surveys. *Science*, *236*, 157–161. https://doi.org/10.1126/science.3563494

Brantingham, P. J., & Brantingham, P. L. (1975). The spatial patterning of burglary. *The Howard Journal of Criminal Justice*, *14*, 11–23. https://doi.org/10.1111/j.1468-2311.1975.tb00297.x

Brantingham, P. J., Glässer, U., Jackson, P., Kinney, B., & Vajihollahi, M. (2008). Mastermind: Computational modeling and simulation of spatiotemporal aspects of crime in urban environments. In L. Liu & J. Eck (Eds.), *Artificial crime analysis systems: Using computer simulations and geographic information systems* (pp. 252–280). Philadelphia, PA: IGI Global.

Brookman, F. (2015). Killer decisions: The role of cognition, affect and "expertise" in homicide. *Aggression and Violent Behavior*, *20*, 42–52. https://doi.org/10.1016/j.avb.2014.12.007

Butler, H., & Gannon, T. (2015). The scripts and expertise of firesetters: A preliminary conceptualization. *Aggression and Violent Behavior*, *20*, 72–81. https://doi.org/10.1016/j.avb.2014.12.011

Carrington, P. (2009). Co-offending and the development of the delinquent career. *Criminology*, *47*, 1295–1329. https://doi.org/10.1111/j.1745-9125.2009.00176.x

Chi, M. (2006). Two approaches to the study of experts' characteristics. In K. Ericsson, N. Charness, P. Feltovich, & R. Hoffman (Eds.), *The Cambridge handbook of expertise and expert performance*. Cambridge, England: Cambridge University Press.

Chi, M., & Bassok, M. (1989). Learning from examples via self-explanations. In L. Resnick (Ed.), *Knowledge, learning and instruction: Essays in honor of Robert Glaser*. Hillsdale, NJ: Erlbaum.

Clare, J. (2011). Examination of systematic variations in burglars' domain-specific perceptual and procedural skills. *Psychology, Crime & Law*, *17*, 199–214. https://doi.org/10.1080/10683160903025810

Clarke, R., & Cornish, D. (1985). Modeling offenders' decisions: A framework for research and policy. *Crime and Justice*, *6*, 147–185.

Cohen, L., & Felson, M. (1979). Social change and crime rate trends: A routine activity approach. *American Sociological Review*, *44*, 588–608. https://doi.org/10.2307/2094589

Cornish, D., & Clarke, R. (Eds.). (1986). *The reasoning criminal: Rational choice perspectives on offending*. New York: Spinger-Verlag.

Copes, H., & Hochstetler, A. (2010). Interviewing the incarcerated: Pitfalls and promises. In W. Bernasco (Ed.), *Offenders on offending: Learning about crime from criminals*. Cullompton, England: Willan.

Coupe, T. (2017). Burglary decisions. In W. Bernasco, J. van Gelder, & H. Elfers (Eds.), *The Oxford handbook of offender decision-making* (pp. 655–683). Oxford, England: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199338801.013.32

Cromwell, P., Olson, J., & Avary, D. (1991). *Breaking and entering: An ethnographic analysis of burglary*. Thousand Oaks, CA: Sage.

Day, A., & Bowen, E. (2015). Offending competency and coercive control in intimate partner violence. *Aggression and Violent Behavior*, *20*, 62–71. https://doi.org/10.1016/j.avb.2014.12.004

DeLisi, M., Beaver, K., Wright, K., Wright, J., Vaughn, M., & Trulson, C. (2011). Criminal specialization revisited: A simultaneous quantile regression approach. *American Journal of Criminal Justice*, *36*, 73–92. https://doi.org/10.1007/s12103-010-9083-1

DeLisi, M., Nelson, E., Vaughn, M., Boutwell, B., & Salas-Wright, C. (2016). An epidemiological study of burglary offenders: Trends and predictors of self-reported arrests for burglary in the united states, 2002–2013. *International Journal of Offender Therapy and Comparative Criminology*, *62*, 1107–1127. https://doi.org/10.1177/0306624X16670178

Ekblom, P., & Hirschfield, A. (2014). Developing an alternative formulation of SCP principles—the Ds (11 and counting). *Crime Science*, *3*, 1–11. https://doi.org/10.1186/s40163-014-0002-5

Elffers, H., Reynald, D., Averdijk, M., Bernasco, W., & Block, R. (2008). Modelling crime flow between neighbourhoods in terms of distance and of intervening opportunities. *Crime Prevention and Community Safety*, *10*, 85–96.

Endsley, M. (2006). Expertise and situation awareness. In K. A. Ericsson, N. Charness, P. Feltovich, & R. Hoffman. (Eds.), *The Cambridge handbook of expertise and expert performance* (pp. 633–652). Cambridge, England: Cambridge University Press. https://doi.org/10.2277/0521600812

Ericsson, K. A. (1996). *The road to excellence: The acquisition of expert performance in the arts and sciences, sports and games*. New York: Erlbaum.

Ericsson, K. A. (2003). Valid and non-reactive verbalization of thoughts during performance of tasks: Toward a solution to the central problems of introspection as a source of scientific data. *Journal of Consciousness Studies*, *10*, 1–18.

Ericsson, K. A. (2006). An introduction to the Cambridge handbook of expertise and expert performance: Its development, organization, and content. In K. A. Ericsson, N. Charness, P. Feltovich, & R. Hoffman. (Eds.), *The Cambridge handbook of expertise and expert performance* (1st ed., pp. 3–20). Cambridge, England: Cambridge University Press. https://doi.org/10.2277/0521600812

Ericsson, K. A., & Kintsch, W. (1995). Long-term working memory. *Psychological Review*, *102*, 211–245. https://doi.org/10.1037/0033-295X.102.2.211

Ericsson, K. A., & Simon, H. (1993). *Protocol analysis; verbal reports as data* (Revised ed.). Cambridge, MA: Bradford Books/MIT Press.

Farrington, D., & Welsh, B. (2007). *Saving children from a life of crime: Early risk factors and effective interventions*. Oxford, England: Oxford University Press.

Federal Bureau of Investigation. (2009). *Crime in the United States: Clearance rates*. Washington, DC: U.S. Department of Justice, Criminal Justice Division. Retrieved from http://www2.fbi.gov/ucr/cius2009/offences/clearances/index.html

Fiske, S., & Taylor, S. (1991). *Social cognition* (2nd ed.). New York: McGraw-Hill.

Fortune, C., Bourke, P., & Ward, T. (2015). Expertise and child sex offenders. *Aggression and Violent Behavior*, *20*, 33–41. https://doi.org/10.1016/j.avb.2014.12.005

Fox, B., & Farrington, D. (2016). Behavioral consistency among serial burglars: Evaluating offense style specialization using three analytical approaches. *Crime & Delinquency*, *62*, 1123–1158. https://doi.org/10.1177/0011128714540275

Garcia-Retamero, R., & Dhami, M. K. (2009). Take-the-best in expert-novice decision strategies for residential burglary. *Psychonomic Bulletin & Review*, *16*, 163–169. https://doi.org/10.3758/PBR.16.1.163

Gottfredson, M., & Hirschi, T. (1990). *A general theory of crime*. Stanford, CA: Stanford University Press.

Graham, J. (2009). Missing data analysis: Making it work in the real world. *Annual Review of Psychology*, *60*, 549–576. https://doi.org/10.1146/annurev.psych.58.110405.085530

Grasmick, H., Tittle, C., Bursik, R., & Arneklev, B. (1993). Testing the core empirical implications of Gottfredson and Hirschi's general theory of crime. *Journal of Research in Crime and Delinquency*, *30*, 5–29. https://doi.org/10.1177/00

Hirschi, T. (1986). On the compatibility of rational choice and social control theories of crime. In D. Cornish & R. Clarke (Eds.), *The reasoning criminal: Rational choice perspectives on offending* (pp. 105–118). New York: Spinger-Verlag.

Holt, T., Bossler, A., & Seigfried-Spellar, K. (2015). *Cybercrime and digital forensics: An introduction*. Oxford, England: Routledge.

Homel, R., Macintyre, S., & Wortley, R. (2014). How burglars decide on targets: A computer based scenario approach. In B. Lelerc & R. Wortley (Eds.), *Cognition and crime: Offender decision making and script analysis* (pp. 26–47). Oxford, England: Routledge.

Jeffery, C. R. (1971). *Crime prevention through environmental design*. Thousand Oaks, CA: Sage.

Johnson, E., & Payne, J. (1986). The decision to commit a crime: An information processing analysis. In D. Cornish & R. Clarke. (Eds.), *The reasoning criminal: Rational choice perspectives on offending* (pp. 170–185). New York: Spinger-Verlag.

Kahneman, D. (2011). *Thinking, fast and slow*. New York: Farrar, Strauss, Giroux.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica*, *47*, 263–291.

Klein, G. (1993). A recognition-primed decision (RPD) model of rapid decision making. In G. Klein, J. Orasanu, R. Calderwood, & C. Zsambo (Eds.), *Decision making in action: Models and methods* (pp. 138–147). Englewood Cliffs, NJ: Ablex.

Langton, S., & Steenbeek, W. (2017). Residential burglary target selection: An analysis at the property-level using Google Street View. *Applied Geography*, *86*, 292–299. https://doi.org/10.1016/j.apgeog.2017.06.014

Little, R., & Rubin, D. (2002). *Statistical analysis with missing data* (2nd ed.). New York: Wiley.

Logan, G. D. (1988). Toward an instance theory of automatization. *Psychological Review*, *95*, 492–527. https://doi.org/10.1037/0033-295X.95.4.492

Logie, R., Wright, R., & Decker, S. (1992). Recognition memory performance and residential burglary. *Applied Cognitive Psychology*, *6*, 109–123. https://doi.org/10.1002/acp.2350060203

Lundqvist, T. (2005). Cognitive consequences of cannabis use: Comparison with abuse of stimulants and heroin with regard to attention, memory and executive functions. *Pharmacology, Biochemistry, and Behavior*, *81*, 319–330. https://doi.org/10.1016/j.pbb.2005.02.017

Maguire, M., & Bennett, T. (1982). *Burglary in a dwelling: The offence, the offender and the victim*. London, England: Ashgate.

Malleson, N., Heppenstall, A., & See, L. (2010). Crime reduction through simulation: An agent-based model of burglary. *Computers, Environment and Urban Systems*, *3*, 236–250. https://doi.org/10.1016/j.compenvurbsys.2009.10.005

Meenaghan, A., Nee, C., van Gelder, J., Otte, M., & Vernham, Z. (2018). Getting closer to the action: Using the Virtual Enactment Method to understand burglary. *Deviant Behavior*, *39*, 437–460. https://doi.org/10.1080/01639625.2017.1407104

Mohler, G., Short, M., Malinowski, S., Johnson, M., Tita, G., Bertozzi, A., & Brantingham, P. J. (2015). Randomized controlled field trials of predictive policing. *Journal of the American Statistical Association*, *110*, 1399–1411. https://doi.org/10.1080/01621459.2015.1077710.

Monahan, K., & Piquero, A. (2009). Investigating the longitudinal relation between offending frequency and offending variety. *Criminal Justice and Behavior*, *36*, 653–673. https://doi.org/10.1177/0093854809335527

Montero, B. (2016). *Thought in action: Expertise and the conscious mind*. Oxford, England: Oxford University Press.

Morin, A. (2006). Levels of consciousness and self-awareness: A comparison and integration of various neurocognitive views. *Consciousness and Cognition*, *15*, 358–371.

Nee, C. (2010). Research on residential burglary: Ways of improving validity and participants' recall when gathering data. In W. Bernasco (Ed.), *Offenders on offending: Learning about crime from criminals* (pp. 231–245). Devon, England: Willan.

Nee, C., & Meenaghan, A. (2006). Expert decision-making in burglars. *British Journal of Criminology*, *46*, 935–949. https://doi.org/10.1093/bjc/azl013

Nee, C., & Taylor, M. (2000). Examining burglars' target selection: Interview, experiment or ethnomethodology? *Psychology, Crime & Law*, *6*, 45–59. https://doi.org/10.1080/10683160008410831

Nee, C., & Vernham, Z. (2016). Expertise and its contribution to the notion of protective factors in offender rehabilitation and desistance. *Aggression and Violent Behavior*, *32*, 37–44. https://doi.org/10.1016/j.avb.2016.12.004

Nee, C., & Ward, T. (2015). Review of expertise and its general implications for correctional psychology and criminology. *Aggression and Violent Behavior*, *20*, 1–9. https://doi.org/10.1016/j.avb.2014.12.002

Nee, C., White, M., Woolford, K., Pascu, T., Barker, L., & Wainwright, L. (2015). New methods for examining expertise in burglars in natural and simulated environments: Preliminary findings. *Psychology, Crime & Law*, *21*, 507–513. https://doi.org/10.1080/1068316X.2014.989849

Nieuwbeerta, P., Blokland, A., Piquero, A., & Sweeten, G. (2011). A life-course analysis of offense specialization across age: Introducing a new method for studying individual specialization over the life course. *Crime & Delinquency*, *57*, 3–28. https://doi.org/10.1177/0011128710376336

Ó Ciardha, C. (2015). Experts in rape: Evaluating the evidence for a novice-to-expert continuum in the offense behavior and cognition of sexual offenders. *Aggression and Violent Behavior*, *20*, 26–32. https://doi.org/10.1016/j.avb.2014.12.003

Paternoster, R., Dean, C., Piquero, A., Mazerolle, P., & Brame, R. (1997). Generality, continuity and change in offending careers. *Journal of Quantitative Criminology*, *13*, 231–266. https://doi.org/10.1007/BF02221092

Potochnik, A. (2017). *Idealization and the aims of science*. Chicago: University of Chicago Press.

Pratt, T., & Cullen, F. (2000). The empirical status of Gottfredson and Hirschi's general theory of crime: A meta-analysis. *Criminology*, *38*, 931–964. https://doi.org/10.1111/j.1745-9125.2000.tb00911.x

Rengert, G., & Wasilchick, J. (1985). *Suburban burglary: A tale of two suburbs*. Springfield, MO: Charles C Thomas.

Reynald, D., & Leclerc, B. (2018). What could be the future of rational choice for crimeprevention? In. B. Leclerc & D. Reynald (Eds.), *The future of rational choice for crime prevention* (pp. 1–5). London: Routledge. https://doi.org/10.4324/9781315441207

RnR Market Research. (2017). *Security solutions market by type [products (fire protection, video surveillance, access control) and services (system integration, remote monitoring, fire protection, VSaaS, ACaaS)], End-use industry, and geography—Global forecast to 2022*. Retrieved from http://www.rnrmarketresearch.com/home-security-solutions-market-global-forecast-analysis-2012-2017-market-report.html

Rogers, R., & Robbins, T. (2001). Investigating the neurocognitive deficits associated with chronic drug misuse. *Current Opinion in Neurobiology*, *11*, 250–257.

Ross, R., & Hilborn, J. (2008). *Rehabilitating rehabilitation: Neurocriminology for prevention and treatment of antisocial behaviour*. Ottawa, Ontario: Cognitive Centre of Canada.

Safewise Report. (2017). *10 surprising home burglary stats and facts*. Retrieved from https://www.safewise.com/blog/8-surprising-home-burglary-statistics

Sampson, R., & Laub, J. (1993). *Crime in the making: Pathways and turning points through life*. Cambridge, MA: Harvard University Press.

Sentencing Council. (2011). *Burglary offences: Definitive guideline*. Retrieved from https://www.sentencingcouncil.org.uk/wpcontent/uploads/Burglary_Definitive_Guideline_web_final.pdf

Shanteau, J. (1992). How much information does an expert use? Is it relevant? *Acta Psychologica*, *81*, 75–86. https://doi.org/10.1016/0001-6918(92)90012-3

Shiffrin, R., & Schneider, W. (1977). Controlled and automatic human information processing: II. perceptual learning, automatic attending, and a general theory. *Psychological Review*, *84*, 127–190. https://doi.org/10.1037/0033-295X.84.2.127

Shover, N. (1973). The social organization of burglary. *Social Problems*, *20*, 499–514. https://doi.org/10.2307/799711

Shover, N. (1996). *Great pretenders: Pursuits and careers of persistent thieves*. Boulder, CO: Westview Press.

Smith, K., Taylor, P., & Elkin, M. (2013). *Crime detected in England and Wales 2012/2013*. London, England: Home Office Statistical Bulletin. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/224037/hosb0213.pdf

Snook, B., Dhami, M., & Kavanagh, J. (2011). Simply criminal: Predicting burglars' occupancy decisions with a simple heuristic. *Law and Human Behavior*, *35*, 316–326. https://doi.org/10.1007/s10979-010-9238-0

Spelman, W. (1994). *Criminal incapacitation*. New York: Plenum.

Taylor, M., & Nee, C. (1988). The role of cues in simulated residential burglary—A preliminary investigation. *British Journal of Criminology*, *28*, 396–401. https://doi.org/10.1093/oxfordjournals.bjc.a047736

Topalli, V. (2005). Criminal expertise and offender decision-making: An experimental analysis of how offenders and non-offenders differentially perceive social stimuli. *British Journal of Criminology*, *45*, 269–295. https://doi.org/10.1093/bjc/azh086

Topalli, V., Jacques, S., & Wright, R. (2015). “It takes skills to take a car”: Perceptual and procedural expertise in carjacking. *Aggression and Violent Behavior*, *20*, 19–25. https://doi.org/10.1016/j.avb.2014.12.001

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology*, *53*, 1–25. https://doi.org/10.1146/annurev.psych.53.100901.135114

Van Gelder, J. L., Elffers, H., Reynald, D., & Nagin, D. (2013). Introduction: Affect and cognition in criminal decision making: Between rational choices and lapses of self-control. In J. L. Van Gelder, H. Elffers, D. Reynald, & D. Nagin (Eds.), *Affect and cognition in criminal decision making*. Abingdon, England: Routledge.

Van Gelder, J. L., Nee, C., Otte, M., Demetriou, A., van Sintemaartensdijk, I., & van Prooijen, J. W. (2017). Virtual burglary: Exploring the potential of virtual reality to study burglary in action. *Journal of Research in Crime and Delinquency*, *54*, 29–62. https://doi.org/10.1177/0022427816663997

Vernham, Z., & Nee, Z. (2016). Dysfunctional expertise and its relationship with dynamic risk factors in offenders. *Psychology, Crime & Law*, *22*, 47–67. https://doi.org/10.1080/1068316X.2015.1109090

Vieraitis, L., Copes, H., Powell, Z., & Pike, A. (2015). A little information goes a long way: Expertise and identity theft. *Aggression and Violent Behavior*, *20*, 10–18. https://doi.org/10.1016/j.avb.2014.12.008

Ward, T. (1999). Competency and deficit models in the understanding and treatment of sexual offenders. *Journal of Sex Research*, *36*, 298–305. https://doi.org/10.1080/00224499909552000

Witmer, B., & Singer, M. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence*, *7*, 225–240.

Wright, R., & Decker, S. (1994). *Burglars on the job: Streetlife and residential break-ins*. Boston: Northeastern University Press.

Wright, R., Logie, R., & Decker, S. (1995). Criminal expertise and offender decision making: An experimental study of the target selection process in residential burglary. *Journal of Research in Crime and Delinquency*, *32*, 39–53. https://doi.org/10.1177/0022427895032001002

AUTHOR BIOGRAPHIES

Claire Nee is the director of the International Centre for Research in Forensic Psychology, University of Portsmouth, U.K., where she coordinates research on offender cognition, detecting deception, and memory in psycho-legal settings. Her work is focused on cognitive and behavioral aspects of expertise in offenders and methodologies to understand better the offender’s insight on their own behavior.

Jean-Louis van Gelder is a full professor at the Psychology of Conflict, Risk & Safety Department at the University of Twente. His research interests are focused on criminal decision making, emotions, short-term mindsets, multiple self-models, personality, virtual reality, and innovative research methods.

Marco Otte, MA, spent more than 15 years working in the archeological industry, where he occupied several management positions. Currently, he is in charge of the Tech Labs of the Network Institute at the VU University Amsterdam. He fully participates in academic research as advisor, technical supporter, technical creator, and academic content.

Zarah Vernham is a senior lecturer at the Department of Psychology, University of Portsmouth. She has interests in two research areas: 1) offending cognition, emotion and behavior; and 2) deception detection through investigative interviewing. She is developing virtual environments to study the navigation strategies of child sex offenders.

Amy Meenaghan is a PhD candidate in the Department of Psychology, University of Portsmouth on “The development of dysfunctional expertise in burglars: Pathways into crime and their implications for offender rehabilitation and situational crime prevention.” She uses the virtual enactment method to capture quantitative and qualitative aspects of burglar expertise.

How to cite this article: Nee C, van Gelder J-L, Otte M, Vernham Z, Meenaghan A. Learning on the job: Studying expertise in residential burglars using virtual environments. *Criminology*. 2019;1–31. https://doi.org/10.1111/1745-9125.12210

APPENDIX

Summary of multivariate analysis with offenders with no qualifications removed (burglars: $n = 44$; other offenders: $n = 40$; nonoffenders: $n = 55$)

Variable	F or χ^2 value	p value
Scoping the environment	3.97	.02
Preference of end of terrace	4.76	.09
Preference for entry at rear of target	6.62	.04
Time spent in house	2.39	.09
Proportion of time spent on each floor	Burglars = 49.60	<.00
	Other offenders = 24.62	<.00
	Nonoffenders = 54.24	<.00
Distance traveled in house	.18	.82
Proportion of distance on each floor[a]	Burglars = 84.99	<.00
	Other offenders = 35.27	<.00
	Nonoffenders = 105.49	<.00
Weight of items	3.10	.04
Volume of items	3.33	.04
Number of items[b]	1.73	.18
Total value of items	.85	.43
Low value items[c]	2.08	.13
Mid-value items	2.57	.08
Large high-value items	.54	.58
Small high-value items	.62	.54
7 most valuable items	5.08	.01

Note: Pairwise comparisons displayed the same degree of significance as the larger analysis unless otherwise indicated.

[a] Pairwise comparisons differed in that burglars were significantly different from nonoffenders ($p < .001$) but not from other offenders ($p = .45$).

[b] The F value differed as it did not approach a significant difference between groups, but means were identical to the larger analysis (Burglars: $M = 15$ [7.59]; other offenders: $M = 17$ [11.41]; nonoffenders: $M = 20$ [15.25]).

[c] The F value differed as it did not approach a significant difference between groups; however, pairwise comparisons showed a significant difference between burglars and nonoffenders ($p = .04$).