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Article in *European Journal of Criminology* · June 2019

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European Journal of Criminology
1–22

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Abstract

More than two decades after the publication of Cornish's seminal work about the script-theoretic approach to crime analysis, this article examines how the concept has been applied in our community. The study provides evidence confirming that the approach is increasingly popular; and takes stock of crime scripting practices through a systematic review of over 100 scripts published between 1994 and 2018. The results offer the first comprehensive picture of this approach and highlight new directions for those interested in using data from cyber-systems and the Internet of Things to develop effective situational crime prevention measures.

Keywords

Crime commission process, crime script, modus operandi, scenario, situational crime prevention

Background

There exist many approaches to crime reduction. Whereas the majority concentrate on the *propensity* to commit crime, situational crime prevention (SCP) operates by altering potential offenders' judgements of risk and reward. Specifically, it seeks to deter them from taking certain courses of action by influencing their perception of opportunities, typically at or near the time and place of its envisaged commission (Clarke, 1997); 25 SCP techniques have been distinguished, such as changing the perceived effort, reward

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and viable excuses associated with the translation of opportunity into criminal action (Bullock, Clarke, and Tilley, 2010). Supported by a raft of empirical studies, Clarke (2009: 3) has claimed that those techniques have been successfully applied to a wide variety of crimes, including organized crime and terrorism, and could, with the necessary ingenuity, be applied across the whole spectrum of crime.

For efficacy, interventions must be tailored to the crimes they are meant to address (Goldstein, 1979). For this reason, practitioners are encouraged to formulate and analyse problems before settling on a response (Borrion et al., 2019). To reduce crime risks in public space, for instance, problem-solving models recommend analysts to collect data that can assist in identifying the crime events likely to occur in such settings, model the sequences of activities that form their crime commission processes, determine the situational conditions that permit or facilitate them, settle on the environmental conditions within which offenders are likely to operate, and identify factors that influence their decisions to commit certain crimes, substitute one offence for another or desist from any further criminal action (Cornish and Clarke, 2003).

Conscious that the development of crime-specific interventions requires a detailed understanding of the factors influencing decisions to commit crime, Cornish introduced the script-theoretic approach to crime analysis: 'a way of generating, organising, and systematizing knowledge about the procedural aspects and procedural requirements of crime commission' (Cornish, 1994a, 1994b). In essence, crime scripts are models that describe 'sequences of predictable actions, locations, and roles that constitute [crime] events' (Bennett, 1993). They were recently described by Eklom and Gill (2016) as 'abstracted descriptions of a particular kind of behavioural process, namely structured sequences of behaviour extended over time and perhaps space, which could be considered functionally self-contained units or subunits of longer sequences'.

The script-theoretic approach has a lot to offer to crime analysts. Studies have referred to it as a tool for *eliciting the offender's behaviour and the rationale for their decisions* (Beauregard and Martineau, 2015; Beauregard, Proulx, et al., 2007; Brookman et al., 2011; Chiu et al., 2011; Gamman et al., 2012; Hagan and Levi, 2004; Hobbs et al., 2005; Lavorgna, 2015; Lord and Levi 2017; Meijerink, 2013; Meyer, 2013; Meyer et al., 2015; Willison, 2008; Willison and Siponen, 2006; Wortley and Mazerolle, 2013), and others have highlighted its utility in *organizing existing knowledge about the requirements of crime commission* such as the skills or resources that criminals need to deploy in order to execute a crime (Balembe and Beauregard, 2013; Basamanowicz, 2011; Bichler et al., 2013; Cornish, 1994b; De Vries, 2012, 2013; Gilmour, 2014; Le, 2013; Leontiadis, 2014; Meijerink, 2013).

As with many techniques, the practice of crime scripting has happened rather organically, with limited top down guidance or coordination between researchers. More than two decades after the publication of Cornish's seminal article, we believe it is now time to draw a contemporary picture of crime scripting practices. The first objective of this study was to test the claim that the script-theoretic approach has been increasingly popular in recent years (see Eklom and Gill, 2016; Leclerc, 2013, 2017). If confirmed, this trend would be an indicator for one or both of two reasons: it might imply that more empirical examples are now available to demonstrate the use of this approach as a potential crime reduction tool, and/or it might reflect an

expansion of the crime script community, and encourage others to learn and apply this approach.

The second objective of this study was to compile a list of references that crime analysts could consult to find scripts. As time goes by, it is becoming increasingly difficult to keep track of what types of crime have been scripted and hence to identify existing gaps. Although illustrative lists can be found in the literature (for example, Borrión, 2013; Leclerc, 2013), none of them represents an exhaustive resource. As a result, certain crime scripts might not be used (if analysts are unaware of their existence) and knowledge gaps are still difficult to identify. By compiling the first comprehensive catalogue of relevant publications, this work can therefore enhance the impact of published research and stimulate new developments in this field.

The third objective of this review was to take stock of crime scripting practices. Although there is no unique scripting method (Brayley et al., 2011), little is known about the diversity of methods used. For this reason, we decided to examine how researchers identify relevant data sources, select visualization models, and assess the scripts they generate. Carefully analysed, this information can be used to create guidelines and training materials for crime reduction practitioners, identify methodological issues, and ultimately support the development of high-quality crime scripts.

The fourth objective of this study was to identify synonyms of the term ‘crime script’ that are used by those familiar with Cornish’s work. In engineering, for example, similar concepts – use cases and business process models – were proposed several decades ago to represent how socio-technological systems work and how users interact within them (Claus et al., 1979). Identifying those will help raise awareness about the knowledge, models, techniques and tools that could be borrowed from other fields to improve the quality of crime scripts.

Method

Overall approach

To take stock of crime scripting practices, we have conducted a systematic review of relevant studies published between 1 January 1994 and 31 December 2018. Systematic reviews are commonly used in the field of crime prevention (for example, Bowers et al., 2011; Sidebottom et al., 2015; Snook et al., 2007) and are generally considered well suited to produce up-to-date summaries of studies in an area, give an objective collation of results and produce reliable recommendations (Gough et al., 2012). This research was conducted following the stages typically found in systematic reviews (for example, Gough et al., 2012; Kitchenham and Charters, 2007; Wright et al., 2007): *Formulating the Objectives, Searching the Literature, Literature Selection, Data Extraction and Data Analysis*.

Formulating the objectives

As mentioned in the previous section, the four questions investigated in this work relate to the diffusion and application of this approach within but also beyond criminology:

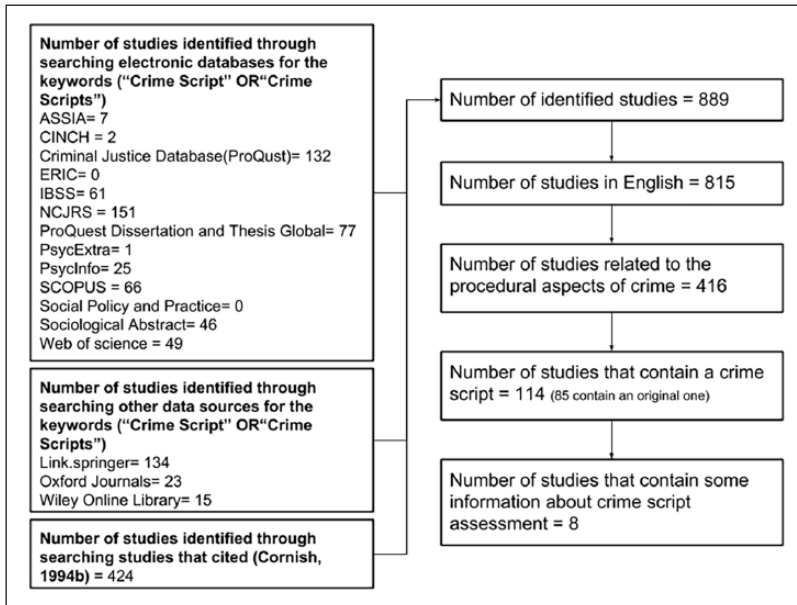


Figure 1. Stages of the screening process.

1. Has the script-theoretic approach gained traction since Cornish's seminal article was published?
2. What types of crime have been scripted during that period?
3. What methods have been used to generate and evaluate crime scripts?
4. Under what other names are crime scripts known in other disciplines?

Searching the literature

The search was conducted through two mechanisms: (1) keyword search (using the wild-card term 'crime script*') of relevant data sources including grey literature and dissertation databases, and (2) forward citation search based on the primary article in this area (Cornish, 1994b). The search spans the period starting with the publication of this article and ending in 2018. As shown in Figure 1, 13 electronic databases were searched: ASSIA (Applied Social Sciences Index and Abstracts), CINCH (Australian Criminology Database), Criminal Justice Database (ProQuest), ERIC (Education Resources Information Center), IBSS (International Bibliography of Social Sciences), NCJRS (National Criminal Justice Reference Service), ProQuest theses and dissertations, PsycINFO, PsycEXTRA, SCOPUS, Social Policy and Practice, Sociological Abstracts, and Web of Science. In addition, three other data sources were used: Link.springer, Oxford Journals and Wiley Online Library. These were used in similar projects (for example, Bowers et al., 2010, 2011; Johnson et al., 2015; Sidebottom et al., 2015) or were flagged when searching through multidisciplinary search engines such as British Library Explorer and Google Scholar. Despite criticisms regarding the use of Google

Scholar in systematic reviews (see Boeker et al., 2013), we decided to use it to conduct a forward citation search because the main article, Cornish (1994b), was not available in any of the above data sources.

Literature selection

Three inclusion criteria were adopted to screen the identified publications:

- *Criterion 1: The publication is written in English.*
- *Criterion 2: The publication contains the word 'script' in its body AND makes a non-marginal reference to crime scripts.*
- *Criterion 3: The publication concerns the procedural aspects or procedural requirements of crime, as defined in Cornish (1994b).*

The first criterion was introduced because of our limited language skills and our lack of confidence in the results generated by a translating tool (for example, Google Translate). However, this decision was considered acceptable after a search on Google Scholar established that 92 percent of the articles identified are written in English. The search was repeated two years later and corroborated these results. Furthermore, some of the articles discarded owing to the first criterion might have been translated into English, in which case they would be included in our results. The second criterion allowed a wide range of publications to be considered (including those referring to the terms 'script', 'crime script', 'script-theoretic approach', 'cognitive script', 'offence script' or 'crime commission script'), while excluding publications in which these terms appear only in a footnote or reference. The third criterion was used to discriminate between the different meanings of the term 'crime script', and to discard the publications that have no direct semantic relation to Cornish's approach, especially those concerning 'movie scripts' or 'news scripts' (for example, Gilliam and Iyengar, 2000) .

Data extraction and analysis

Publications and authors. All the publications selected at the screening stage were then reviewed by one of us, and the following data extracted: study title, publication date and author name. We counted the annual number of manuscripts published in the period of interest, and generated two cumulative frequency distributions that represent the number of relevant publications each year (see Figure 2). In addition, the list of publications was used to estimate the size of the community by calculating the number of authors who have published on this topic over time.

Crime types. The types of crime discussed in the selected studies were identified in the title or abstract, or, when they were not found there, in the body of the articles. We also searched for the presence of crime scripts within the shortlisted articles. This was done by searching for synonyms of the term 'crime script' and looking for diagrams, figures, tables or narratives that describe a crime commission process. For every identified article that contains a crime script, we both independently recorded the type of crime that was

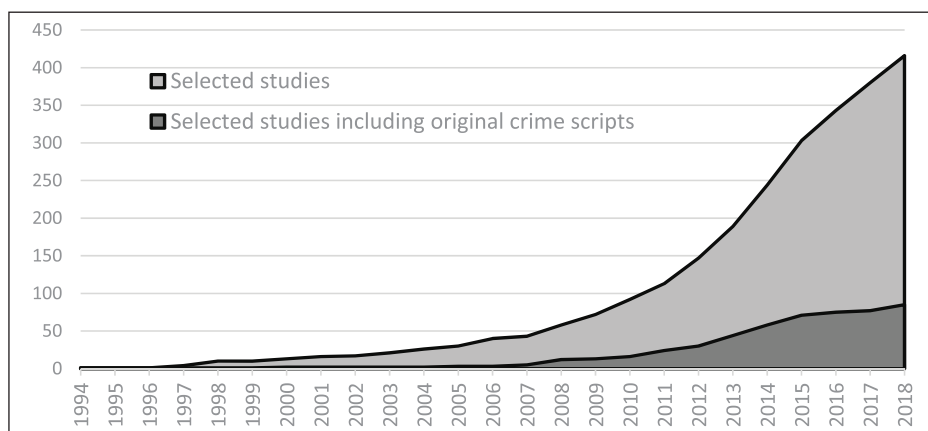


Figure 2. Cumulative frequency distribution showing the number of publications mentioning the script-theoretic approach (dark grey) or including an original crime script (light grey), over time (1994–2018).

modelled, and discussed them when the results were different. For this, we used a typology inspired by the categories of offences used in the British Crime Survey (ONS, 2015). For convenience, we included corruption and fraud scripts within the same category, and did the same for theft and robbery offences. As seen in the Results section, some of the scripts can be associated with multiple categories (for example, fraud offences causing environmental damage).

Data sources and visualization models. The articles containing an original crime script were examined by both of us, and the data sources and visualization models that were adopted compiled into a list. Data sources were characterized based on their origins (for example, primary or secondary data) and types (for example, police report, newspaper article).

Verification and validation. Information concerning the quality assessment of crime scripts was gathered by searching for possible variants of the words verification, validation, assessment and evaluation (*verif**, *valid**, *assess**, *evaluat**) in the publications that contain an original crime script. The extracted information was then thematically classified based on the criteria proposed by Borrion (2013). New elements, where appropriate, would be added to the list.

Synonyms. Synonyms of the term ‘crime script’ were identified in an iterative manner, as suggested by Holton (2007). First, synonyms (for example, offence script) were identified in Cornish (1994b). A list of related keywords (for example, *offence*) was then generated based on those and used (in conjunction with a wildcard character) to identify additional synonyms (for example, *offen**) within the selected articles. When a synonym was found that contained a new term (for example, *scenario* in the expression *offending*

scenario), the latter was added to the list of keywords and all selected studies were searched again.

Results

Search results

The search tactics described above returned 889 publications. The aforementioned criteria were then applied to the identified studies, resulting in the inclusion of 416 studies, as shown in Figure 1.

We excluded 473 publications from this study. As explained earlier, 74 of them were written in languages other than English. The three main identified non-English languages were French (22, 30 percent), Dutch (18, 24 percent) and Italian (11, 15 percent). We discarded 23 other publications (written in German, Spanish, Chinese, Portuguese, Finnish, Korean, Swedish, Bosnian, Czech and Greek).

Has the script-theoretic approach gained traction since Cornish's seminal article was published? Figure 2 is a cumulative frequency diagram showing the number of publications directly related to crime scripts between 1994 and 2018. It confirms that the number of publications has increased more rapidly in recent years. Over half of the publications (52 percent) were recorded in the last five years. Within the 114 publications containing a crime script, we identified 105 original scripts in 85 of them (75 percent). Some publications contain multiple scripts about the same or different crime types. Those publications comprise a majority of peer-reviewed articles (49), followed by book chapters (14); theses (12); conference proceedings (6); and reports (4).

Figure 3 indicates that 485 authors contributed to the 416 publications identified as being directly related to crime scripts. The great majority of the authors (75 percent) have published just one article in this list; and only 22 (5 percent) had (co-)authored five or more in that period. This suggests there are actually very few crime script experts or that they do not publish their scripts. It also shows that the number of authors and the number of publications have increased in a similar fashion over time.

What types of crime have been scripted during that period? Not all the reviewed articles were focused on a particular crime type. For instance, Borrion (2013) wrote an article about quality assurance in crime scripting, and Leclerc (2013) discussed an extension of the script-theoretic approach to victims, without focusing on any particular crime type. Of the 416 reviewed studies, about three-quarters could be associated with 157 specific crime types (Figure 4).

Focusing on the 105 scripts identified in the search, we identified numerous crime types that could be classified into eight broad crime categories. Among them, 24 scripts were classified in two categories. The results in Tables 1 and 2 show the following categories are the most prevalent: cybercrime (24 scripts) and corruption and fraud offences (23), followed by robbery and theft offences (19), drugs offences (14), environmental crime (14), violent crime (13), sexual offences (9), and other (13).

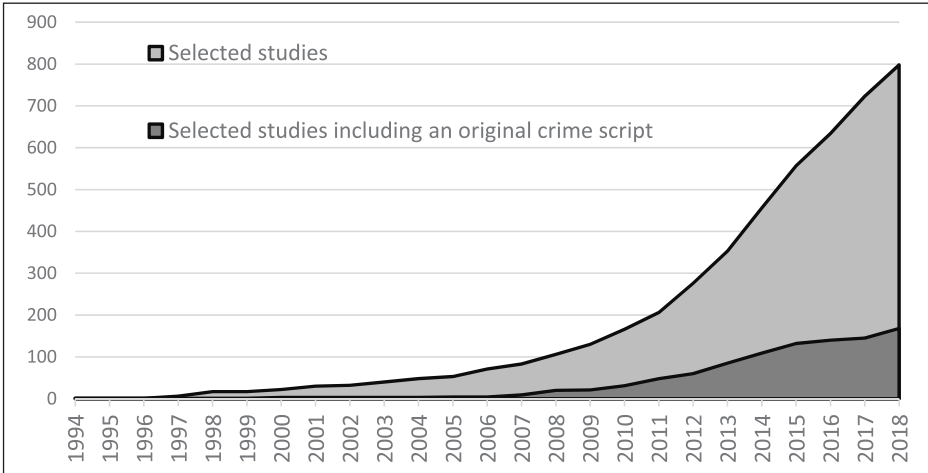


Figure 3. Cumulative frequency distribution showing the number of authors of publications mentioning the script-theoretic approach (dark grey) or including an original crime script (light grey), over time (1994–2018).



Figure 4. Crime types discussed in the selected studies.

That cybercrime tops this list can be attributed to the fact that it is a broad category that covers many crime types, including traditional crimes that have an online component (cyber-enabled crime). In addition, many academics in computer science departments conduct research to find defences against cyber-attacks, which often starts with

Table 1. Number of scripts per crime category (1994–2018).

Crime type	Number of original crime scripts
Cybercrime	24
Corruption and fraud offences	23
Robbery and theft offences	19
Drugs offences	14
Environmental crime	13
Violent crime	13
Sexual offences	9
Other	13

Notes: Some of the identified crime scripts were mapped to multiple crime types. For example, *The process of seafood substitution, short weighting, mislabeling and overtreatment of seafood upon landing* is related to both *Environmental crime* and *Corruption and fraud offences*.

Table 2. Crime types covered by the 105 crime scripts (1994–2018).

Cybercrime	Account takeover (Haelterman, 2016; Willison, 2005); Attacks on online banking (Leukfeldt and Jansen, 2015); Carding (Meijerink, 2013); Cybercrime against electricity infrastructure (Rege, 2012); Internet-related criminal opportunities (Lavorgna, 2014b); Mapping trolling on a cyber attack journey (Somer, Tiido, Sample and Mitchener-Nissen, 2018); Phishing (Leukfeldt, 2014); Physical penetration (Dimkov, Van Cleeff, Pieters, and Hartel, 2010); (Illegal/Warez) release process (Basamanowicz, 2011; Basamanowicz and Bouchard, 2011).
Corruption and fraud offences	Cigarette smuggling (Hiropoulos, Freilich, Chermak and Newman, 2013); Corruption (Rowe, Akman, Smith and Tomison, 2012); Corruption in public procurement of works contracts (Zanella, 2013); Counterfeit alcohol distribution (Lord, Spencer, Bellotti and Benson, 2017); Credit card fraud (van Hardeveld, Webber and O'Hara, 2016); Credit card identity theft (Dehghanniri, Letier and Borrion, 2015); Expense reimbursement fraud (Haelterman, 2016); (Fraudulent) ticket purchase (Hutchings, 2018); Internet-mediated trade in counterfeit pharmaceuticals (Lavorgna, 2014b); Money laundering (Gilmour, 2014); Online auction fraud (Hartel, Junger and Wieringa, 2010); Pharmaceutical counterfeiting (Kennedy, Haberman and Wilson, 2018); The process of fraud and other crimes for gain (Levi, 2008); Stolen card fraud (Haelterman, 2016).
Robbery and theft offences	Armed robbery (Borrion et al., 2017; Leclerc and Wortley, 2013); Auto-theft (Cornish, 1994b); Car theft (Knapik, Schoch, Muller and Kargl, 2012); Metal theft from railway (Ashby, 2016); Pickpocketing (Gentry, 2015); Professional auto theft (Cornish and Clarke, 2002); Ringing script (Morselli and Roy, 2008); Robbery (Gentry, 2015); Shoplifting (Lasky et al., 2015); Snatch theft (Gentry, 2015); Stolen vehicle pathway (Lantsman, 2013); Suburban burglary (Cornish and Clarke, 2008); Subway mugging (Cornish, 1994b); Taxi robbery (Smith and Clarke, 2000); Theft from a moving vehicle (Haelterman, 2016); Theft from churches (Price, Sidebottom, and Tilley, 2014); Theft of electronic products (Ekblom and Sidebottom, 2008); Vehicle theft (Block, 2012; Morselli and Roy, 2008).

(Continued)

Table 2. (Continued)

Sexual offences	Child sex abuse (Leclerc, Wortley and Smallbone, 2011, Leclerc and Wortley, 2013); Child sex trafficking (Brayley, Cockbain and Laycock, 2011); Compensated dating (Li, 2015); Human trafficking (Savona, Giommoni and Mancuso, 2014); Internet-mediated sex trafficking (Lavorgna, 2014b); Offending process of sex offenders (Beauregard and Leclerc, 2007); Sexual assault (Beauregard and Leclerc, 2007); Sexual offences (Cook, Reynald, Leclerc and Wortley, 2018); The tracking of stranger-perpetrator in public places (Beauregard, Rossmo and Proulx, 2007).
Violent crime	Crime script for active shooter event (Osborne and Capellan, 2017); Explosive in rail carriage (Meyer, 2011); Foreign fighting (De Bie, De Poot and Van Der Leun, 2015); Hit-and-run (Hopkins and Chivers, 2018); Hostage taking (Yun and Roth, 2008); Illegal trade in ammunition (De Vries, 2013); Mass shooting (Meyer, 2013); Trade and use of converted firearms (De Vries, 2012); Urban youth violence events (Wilkinson, 2011); Vehicle-borne explosives (Meyer, 2012); Violent crime (Smith, 2008, 2009).
Drugs offences	Cannabis cultivation (Duijn, Kashirin and Sloot, 2014; Duijn and Klerks, 2014); Clandestine drug laboratories—drug manufacturing (Chiu, Leclerc and Townsley 2011); Domestic methamphetamine supply chain (Bright and Delaney, 2013); Drug dealing (Jacques and Bernasco, 2013); Heroin production, importation, and distribution (Le, 2013); Internet-mediated trafficking in synthetic drugs and NPSs (Lavorgna, 2014b); Internet-mediated trafficking in traditional recreational drugs (Lavorgna, 2014b); Online drug trade (Leontiadis and Hutchings, 2015); Open-air drug selling (Sytsma and Piza, 2018).
Environmental crime	Illegal ivory market (Moreto and Lemieux, 2015); Illegal waste dumping (Sahramäki and Kankaanranta, 2017); Illegal waste traffic (Dalla Gasperina, 2014); Illegal hunting, poaching and illegal wildlife trade (Hill, 2015); Internet-mediated wildlife trafficking (Lavorgna, 2014b); Process of removal and transshipment and landing of illegal, unreported and unregulated (IUU) fishing (Petrossian and Pezzella, 2018); Process of seafood substitution, short weighting, mislabeling and overtreatment of seafood upon landing (Petrossian and Pezzella, 2018); Rhino horn and live pet trafficking (Viollaz, Graham, and Lantsman, 2018); Rhino poaching (van Doormaal, Lemieux, and Ruiter, 2018); Waste crime (Tompson and Chainey, 2011); Waste crime script for tyre collection (Baird, Curry and Cruz, 2014); Wildlife crime (Lavorgna, 2013); Wildlife trafficking (Lavorgna, 2014c).
Other crime scripts	Doping (Vakhitova and Bell, 2018); Crimes linked to wind farm creation (Caneppele, Riccardi and Standridge, 2013); Graffiti (Cornish, 1994b); A hypothetical capable guardian script (Leclerc, 2014); A hypothetical handler script (Leclerc, 2014); A hypothetical place manager script (Leclerc, 2014); Intervention script of capable guardians against crime in public settings (Leclerc and Reynald, 2015); Negative posting scenario (Samonas, 2013); Safety script (Leberatto, 2015).

Notes: Some of the identified crime types can be associated with multiple categories (for example, fraud offences and environmental crime). Those are included in only one category to avoid duplicates.

modelling them. The prevalence of cybercrime scripts can also be explained by the fact that data may be more readily available in this field where data transfers (for example, financial transactions) are generally logged in computers and servers. It is noteworthy that fraud offences also come very high in this list, as they often relate to trafficking in goods and counterfeits (for example, alcohol, pharmaceutical and wildlife products) in various sectors.

What methods have been used to generate, visualize and evaluate those scripts?

Crime script generation. Although this review found no study that describes in detail *all* the stages involved in generating, visualizing and evaluating crime scripts, it identified several publications containing information about those stages.

Data sources: Of the 85 selected studies that include at least one original crime script, 60 (71 percent) contain information about data sources used to generate the scripts: 8 publications indicated that their scripts had been created from primary data (Rege, 2012; Jacques and Bernasco, 2013; Li, 2015), 29 scripts were created using a mix of primary and secondary data (for example, Brayley et al., 2011) and 23 scripts were created using just secondary data (for example, Meyer, 2011); 25 publications provided no or ambiguous information about the data used to create the scripts. In several cases, we found that authors had used the basic script structure available in a publication as a starting point, before using primary or secondary data to populate the script with details (for example, Bright and Delaney, 2013).

The secondary datasets reported in those publications were collected from both public and private sector organizations. They consist of court data (Chiu et al., 2011); police reports (Brayley et al., 2011) such as offenders' testimonies (Beauregard, Proulx, et al., 2007); interviews of experts and victims (Leukfeldt, 2014; Willison, 2006); police statistics (De Vries, 2012); surveys (Samonas, 2013; Willison, 2005); video footage (Borrior et al., 2017; Sytsma and Piza, 2018); and synthesis of open data (Deslauriers-Varin and Beauregard, 2010; Lavorgna, 2014a, 2014b; Meijerink, 2013).

Visualization models: Three models have been used to represent the 105 identified crime scripts. The most prevalent models are *tables with narratives* (53 percent) (for example, Cornish, 1994b), followed by *flowcharts with narratives* (37 percent) (for example, Cornish and Clarke, 2008) and *text only* (10 percent) (for example, Beauregard, Proulx, et al., 2007). Some publications that included tables with statistics about the attributes (for example, space, time) of the crime commission process and the actors involved were not considered as crime scripts because they were not sufficient to understand the crime commission process.

Crime script assessment. Borrior (2013) highlighted the importance of applying a formal verification or validation process to assess the quality of the generated crime scripts – see also (Dehghanniri and Borrior, 2016; Hutchings and Holt, 2015). To validate their script, Brayley et al. (2011) indicated they had used it as a 'stimulus for a structured brainstorming session' aimed at identifying interventions. However, idea generation was not constrained by specific practical considerations and the proposed interventions were not evaluated. Moreover, the lack of a comparison group (such as a group of analysts using no script or a low-quality script) in their study means it is difficult to assess the extent

Table 3. Synonyms of the term ‘crime script’ and the number of publications in which they appear.

Synonym	Number of publications
Crime script ^a	328 ^b (79%)
Crime commission process ^a	262 (63%)
Modus operandi ^a	182 (44%)
Scenario	115 (28%)
Offender behaviour ^a	13 (3%)

Notes:

a. Appears in Cornish (1994b).

b. Out of 416 selected studies.

to which the script influenced the outcomes of this process. Chiu et al. (2011) discussed the degree of *completeness* of their script, indicating that the ‘gaps in [their] table reflect script stage-intervention points for which the analysis was not able to reveal sufficient understanding for preventative measures’. They also pointed to some of the limitations caused by the fact that their sample was small and potentially not representative of the population of interest. The main aspect investigated in their study was the reliability of the initial data (data validity), a point also discussed in some other articles – for example, Basamanowicz and Bouchard (2011); Beauregard and Leclerc (2007); Lantsman (2013); Le (2013); Lord et al. (2017); Sytsma and Piza (2018); and Vakhitova and Bell (2018).

What other names are used for the term ‘crime script’? More than 70 synonyms of the term ‘crime script’ were identified in the 416 reviewed publications. Those are often combinations of very similar synonyms for the words ‘crime’ and ‘script’. As shown in Table 3, ‘*crime commission process*’ is the most common expression after ‘crime script’. The first synonym that did not feature in Cornish’s reference publication is ‘scenario’. In this context, this term was found to be mostly used in the risk analysis and information security literature (for example, Borrión and Bouhana, 2012; Dimkov, 2012; Meyer and Ekblom, 2012; Willison, 2006). This word could be used for the search stage in future reviews.

Discussion

Twenty years after

The results of this systematic review constitute the first evidence that the script-theoretic approach has been gaining momentum within the research community, as affirmed by Leclerc (2017). Both the number of publications mentioning this approach and the pool of authors have increased exponentially, with 80 percent of those recorded in the last eight years of the studied period (1994–2018). It is noteworthy that the publications referring to this concept are not limited to a few specialist niches. On the contrary, they concern crime types across a wide spectrum, with the rather broad denomination of ‘cybercrime’ topping the list. Among those, the number of publications that contain at least one original crime script has been increasing in a similar fashion. These trends are

encouraging for the dissemination and recognition of the script-theoretic approach, especially as they might reflect an increase in the creation and use of crime scripts by practitioners more widely. The magnitude of those figures is somewhat less impressive. With only 105 original crime scripts, the knowledge published in this area seems incredibly limited.

There are reasons to believe, however, that the crime scripts identified in this systematic review may not be representative of the overall population of crime scripts:

- The scope of this systematic review was limited to those studies published after 1994 and using the words *crime script(s)* or citing Cornish's reference article. Because of this, only the work of those authors aware of Cornish's work at the time of writing was considered in this review. Publications that include procedural models of crime but make no direct mention of Cornish's concept would not have been included in our analysis.
- Because unpublished crime scripts were not taken into account, the total number of scripts generated in that period could be greater than our estimates by several orders of magnitude. Some scripts may have been created but considered too sensitive to be published (for example, cases where intelligence reports are used as sources of information or where there is a risk that sharing procedural information helps offenders carry out those crimes).
- A more extensive *backward reference searching* strategy (Levy and Ellis, 2006; Tada et al., 1998; Webster and Watson, 2002) could have been used by searching through all the citations of the selected studies. However, this was not possible due to time constraints.

Taking all these points into account, it seems a reasonable conclusion that a lot more crime scripts might have been generated than those identified in this review, including some that describe crime types not unveiled here. Paradoxically, the quality of the scripts we examined is likely to be unrepresentatively high since many of the identified publications are peer-reviewed articles. Given the lack of evidence in support of the quality of published scripts, one may therefore have doubts about that of unpublished scripts. To reiterate our findings, many of the published scripts have been authored by academics without an evident track record of scripting crime: only 5 percent of the identified researchers had authored five or more of the identified publications in the studied period. Little comfort could be found in the reported methodology either: first, most identified scripts have been generated intuitively, without adhering to a strict and recognized scripting protocol; and, second, there was not enough information available to replicate the work reported in those publications, to assess the quality of the scripts, or to ascertain the level of methodological rigour involved in their creation.

Are existing crime scripting methods good enough?

That published scripts are not accompanied by sufficient methodological details (that is, data or specific information about the ways in which they were created) may have more to do with poor reporting than with poor modelling. In fact, legitimate questions could be

raised about the usefulness of formalizing the crime scripting process. Indeed, the establishment of the script-theoretic approach can already be regarded as an unnecessarily complicated attempt to codify and systematize a practice that had been in existence long before being theorized by Cornish. Certainly, it is difficult to imagine how military engineers and security architects managed to create successful arrays of protective measures without framing problems using a script-based approach, and asking questions such as: What steps do most *village attacks* (burglaries) have in common? What can prevent *marauders* (burglars) from penetrating in *villages* (people's homes)? What would offenders do if *defensive walls and watchtowers* (fences and CCTV) were introduced around habitats? And so on.

If crime scripting is useful in finding innovative ways to prevent crime then surely it is worth investing time to think how best to generate, visualize and analyse crime scripts. Are intuitive ways to think about crime processes good enough? Thereby implying that any past or future attempts to explain how to script crime are utterly futile. Perhaps one of the most useful findings emerging from the review is that we did not find enough evidence to answer this question. Simply put, there appears to have been no attempt to empirically assess the contribution of crime scripting techniques in the two decades that have followed the formalization of the script-theoretic approach.

In this context, we can only highlight that more formal crime scripting methods have both advantages and disadvantages. Indeed, it can be hypothesized that providing more structured guidance helps communicate to junior crime analysts what the 'crime scripting' task entails. Greater methodological clarity should logically support their understanding of how to script crime, give them greater confidence in the resulting products, and increase their willingness to engage in problem-solving activities more generally rather than blindly opting for existing security recipes that may not be adapted to the problems of interest. Another possible advantage of using structured methods is that poor performance (that is, an inability to identify suitable crime reduction interventions) could be traced back to specific issues in the method that was prescribed or in the way it was applied, and subsequently addressed. Therefore, more structured methods (and possibly some form of standardization) might be a necessary step to encourage greater integration and comparison of scripts.

However, opponents of structured methods are not without arguments. Indeed, the more detailed crime scripting methods, the more time and resources analysts have to invest in learning and applying them, which makes the script-theoretic approach less accessible and plays against its successful diffusion (Hardy et al., 1995; Yourdon Inc., 1993). Although structured methods are intended to be generic (so they can be applied to many problems), there is always a possibility that they do not contain enough detail and scripters do not find them useful (Gillies and Smith, 1994; Hardy et al., 1995). This may be an issue here, because those methods do not always adapt well to different analytical needs. For instance, the level of specificity needed for the script may vary depending on the complexity of the crime, which could be difficult to communicate with a simple scripting method. Conversely, if the method is overly complicated, scripters may perceive the benefits to be sufficiently high to invest time learning them, in comparison with in-house or intuitive methods (Hardy et al., 1995; Olle et al., 1992).

Without evidence that structured methods can yield substantial improvement, ‘back-of-the-envelope’ scripting might therefore be considered good enough for most problems – even though they could actually offer substantial benefits in terms of crime reduction.

Conclusions

Cornish’s vision for a script-theoretic approach to crime analysis is regarded as a methodological landmark in the analysis of crime and top down rational development of crime reduction measures. Following this approach, analysis of individual crime commission procedures could unveil the factors and mechanisms giving rise to crime, and their comparison could reveal the flexibility, variation and evolution of crime activities. Following this approach, libraries of procedural models – not only effective *modi operandi* but also ineffective ones – would soon prove a formidable resource for identifying interventions. More than two decades later, the work of Cornish is still deeply relevant but his vision has yet to be fully delivered.

Searching for publications that contain the keyword ‘crime script(s)’ or citing Cornish’s seminal article in the 1994–2018 period, our work has shown that the list of published crime scripts, although representing only a subset of all crime scripts, has grown exponentially since Cornish’s seminal article. We noticed that scripts provide information about different aspects of the crime commission process. For example, there are studies that explain how some niche crimes happen in specialized industry sectors (for example, waste crime). To non-specialists at least, the main information provided by those scripts is the basic procedural structure (that is, the sequence of activities) of the studied crime. Other studies are concerned with crimes whose commission processes are simple and/or already known to criminologists (for example, child abuse). For those, the contribution to knowledge is not in the basic structure but in the variations in the crime commission process (for example, alternative activities and relative frequencies), along with the details about the individual or environmental factors that influence it.

Characterized by breadth rather than depth, the pool of crime scripts might reach a steady state once a script has been published for most crime types. At that point, a change of direction might be observed, with the generation and quantitative analysis of multiple and more detailed scripts (that is, tracks) for each crime type. Borrion et al. (2019) also recommended creating scripts to study wider problems (for example, breach of privacy, environmental harm). To accompany this development, it is likely that researchers will start adopting more systematic and transparent crime scripting methods. Already unsupervised algorithms exist that can automatically generate extra sequences of events from video footage. For such techniques to be adopted by crime analysts, convincing evidence will need to be produced about their added value.

Besides the lack of information about the quality of crime scripts, another important shortfall identified in this review is the lack of information about the usefulness of those scripts. Many authors have explained that their scripts were used to identify crime prevention measures. There is, however, no study that empirically examines the usefulness of different existing scripting approaches. For this reason, we recommend carrying out experimental work to ascertain the added value of different crime scripting methods in comparison with others.

Acknowledgements

We are very grateful to the anonymous reviewers and to Professor Ken Pease for their valuable comments.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: We have received funding from EPSRC [Grants No EP/G037264/1 and EP/P011896/2].

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