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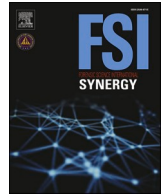
Crime Script Sequencing: An optimal forensic combination for cold case analysis

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ABSTRACT

Criminal cases go cold when investigative leads or forensic testing does not lead to a successful arrest. In these cases, investigators are often keen to use novel methods to derive fresh ideas or insights. Recently, academics from a range of fields, including Psychology, Criminology, and Forensic Sciences have developed a range of new methods and tests to assist with police investigations. The current paper outlines a novel approach to assisting with police cold case investigations: Crime Script Sequencing. The new method combines two leading temporal methods, Crime Script Analysis and Behaviour Sequence Analysis. A real-world cold case, the bombing of Canadian Pacific Airlines Fight 21, is presented and analysed using Crime Script Sequencing to offer readers a guide of how to use the method for other investigations. Impacts, insights, and potential future developments of the method are outlined.

1. Introduction

Advances in forensic science, criminology, and forensic psychology can all help to assist with solving criminal cases [1–3]. There are, however, a large number of unsolved cases—specifically, unresolved murder investigations—many of which are not so easily solved using modern forensic technology and testing. Instead, cold cases often require the synthesis of comparatively circumstantial evidence previously compiled by investigators with the opinion evidence of subject matter experts reviewing that evidence often years later. These cold cases, though sometimes decades old, are still of the utmost importance. Often, family of the victims are still alive and bearing the persistent wounds of not having answers. This has encouraged the development of new methods in criminology to help solve cold cases, when forensic science is lacking [2]. Recently, in the peer-reviewed criminological literature, offence-related timeline methodologies have become an increasingly favoured approach for mapping crimes. New methods, such as Matrix Forecasting [4], Behavioural Fingerprinting [5], and Behaviour Tracking [6] have all been developed to help with cold case investigations. All of these are underpinned by temporal analyses and frameworks [7]. The aim of the current research is to provide another novel approach to working cold cases, based on two leading timeline methods: Crime Script Analysis [8,9] and Behaviour Sequence Analysis [10–12]. The new method, *Crime Script Sequencing (CSS)* will be outlined herein with particular reference to a cold case involving an airliner bombing and ensuing mass murder that occurred in 1965. Like all new and novel analytic methods, this application of the CSS to the case is furnished as an initial guide and framework, from which developments and further testing are encouraged, especially with input from forensic sciences. Each component of CSS will be outlined, followed by an outline of the cold case in question, as well as a general overview of the proposed method. From the outset, the authors note this method is provided as one further tool in the toolkit of cold case investigators; it is not a magic bullet or panacea that might immediately and independently solve a case. The cold case chosen for demonstrative purposes here has also been selected in part due to its vintage and the fact that, while a curiously lesser-known cold case, so much of the original police file is now freely available and within the public record.
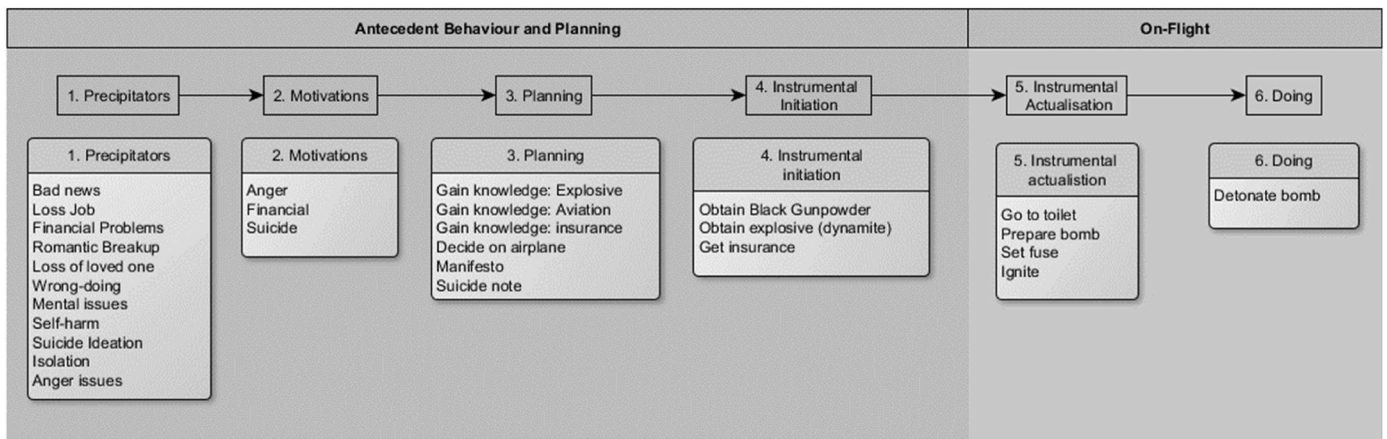

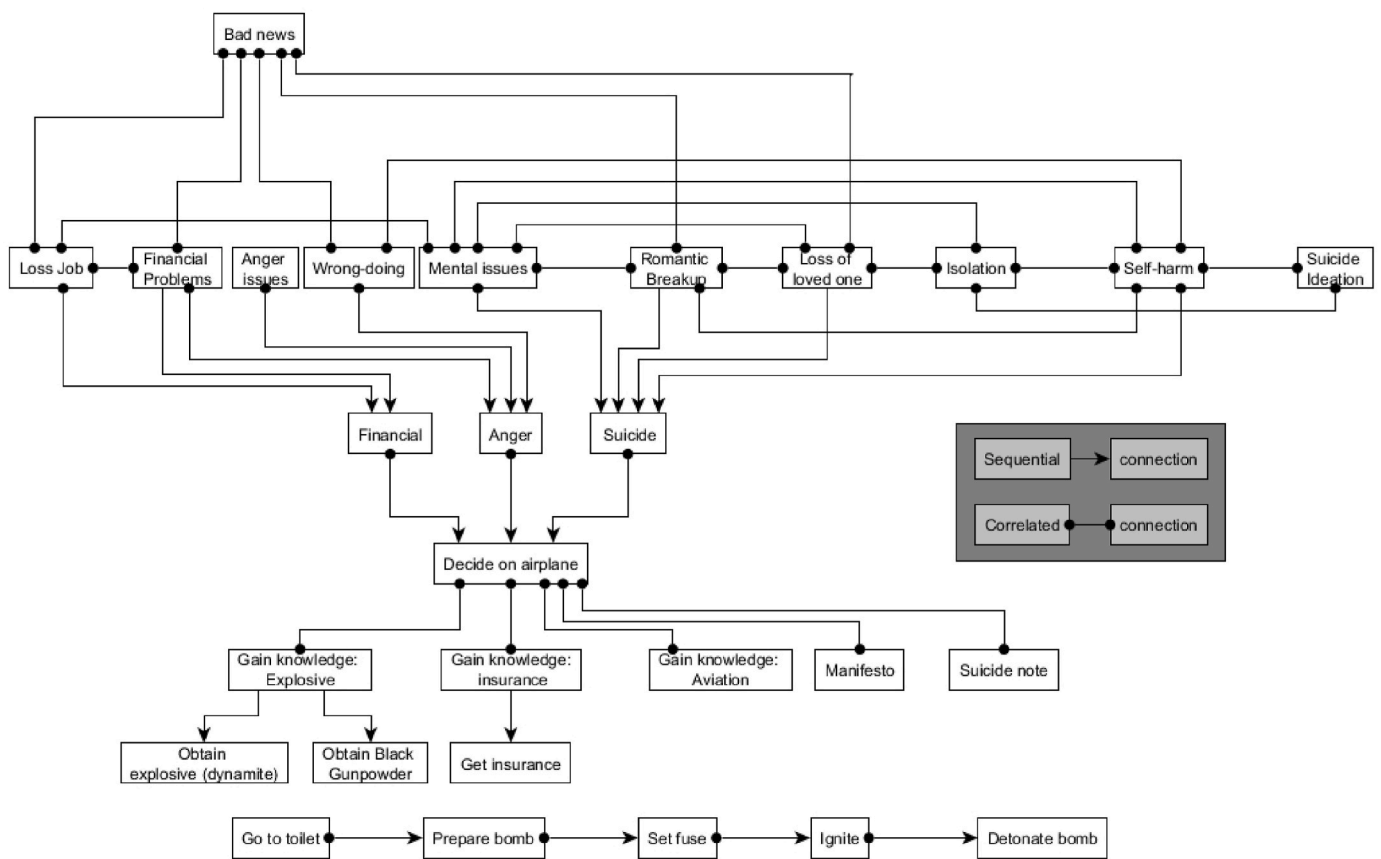**Fig. 1.** Crime Script Analysis of plane bombings.

Fig. 2. Crime Script Sequencing of plan bombings.

1.1. Timeline Toolkit

Crime Script Analysis (CSA) [8] was developed from Cognitive Psychology concepts of scripts and schema [13]. The original script analysis approach outlined general patterns of behaviour, based on an individual's understanding of expected behaviours. For example, when entering a restaurant, we often quickly perceive how to behave based on key features in the environment. If there is a staff member at the door, we are typically taken to a seat, if no staff member greets us, we find our own way to a table and discern whether to order at the bar or wait for a staff member based on whether a number is located on the table. Of course, these scripts are not necessarily foolproof, and often mistakes

occur when we find ourselves in novel circumstances for which we have no script, or else we use the wrong script for the situation. Other conceptualisations of scripts can also be likened to computer scripts that run in a sequential manner from beginning to end. Actors in a play also can be used as an example of individuals literally following a script, with the inclusion of rehearsed scenes that the play passes through to reach the end.

In the same way that we follow scripts in our everyday lives, criminals are presumed to also follow scripts in the development of their crime commission [7,14]. Many goal-oriented crimes have a script that a criminal uses to navigate their behaviours and conduct their crime. As with any repeated behaviours, some of these sequences may become
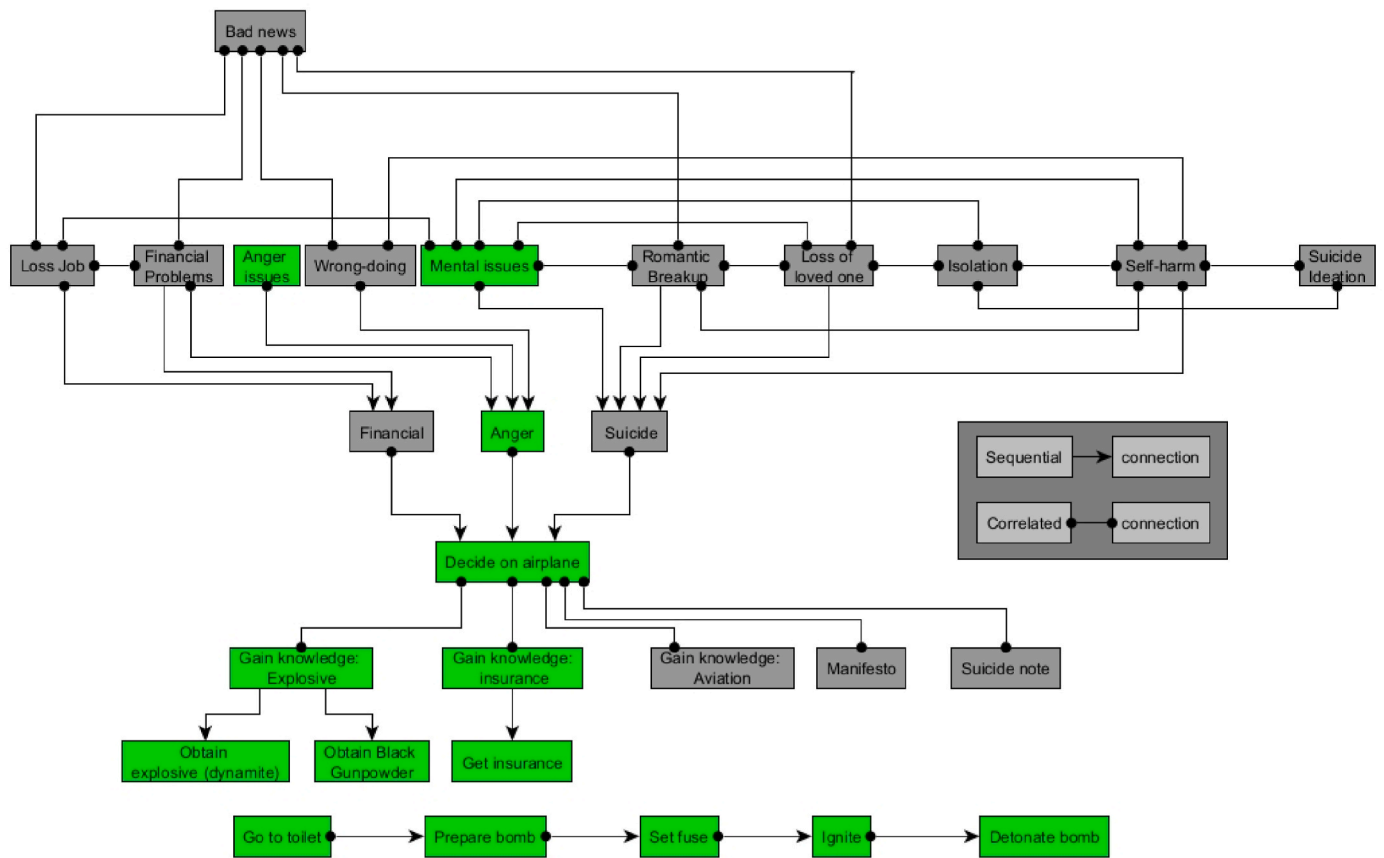
Fig. 3. Crime script sequencing for VANDER MEULEN

automatic or habitual. Many cold cases homicides, however, do not involve serial killers, whose crimes can often be linked through a number of other established methods [15,16]. An additional strength of crime script analysis is the ability to investigate individual crimes and compare them to a database of other, though not identical, substantively similar cases [17]. Investigators and researchers may also use a database of cases to develop a prototypical script for a specific criminal offence and then use that script to understand what behaviours may be missing from the case files. Investigators using CSA may ask, 'are parts of the script missing because of a lack of investigation or evidence, or are they truly missing from the crime?' It may not be possible to answer this immediately, but often when working cold cases, developing new questions is an important first step to finding new answers.

The crime script analysis approach has already been used in a wide range of crimes, including homicides [18,19], sexual assault and rape cases [14,20], drug trafficking [21], and cold cases [2]. In terms of cold cases, developing a crime script is often a useful means of beginning to map the possible pathways a criminal took in the commission of a crime, bearing in mind and accounting for the technological, cultural, procedural standards of the period of the crime. Owing to the very *top down*, expertise-driven nature of crime scripts, developing one for a cold case can facilitate discussion between practitioner and investigator in terms of likely behavioural pathways [22]. In the current case, involving the pre-planned massacre of 52 aircraft passengers and crew, experts from a wide variety of academic and applied sciences were contacted and consulted. Explosives experts provided insight into the type, availability, and complexity of the explosive device used to carry out the bombing. Clinical Psychologists imparted expert advice on the motivations and cognitions of suicidal people (owing to the fact the suspect was a passenger on board). Finally, criminologists provided expert insight into lone-actor terrorists, especially those who detonated delayed ignition bombs and yet showed no indication of using the delay to prevent their

own death or elude detection. In this way, CSA provides a platform for and a unified framework through which multiple experts are able to provide input and help progress a case in a systematic, interdisciplinary manner.

Of course, one of the chief limitations of crime script analysis is that scripts are often subjectively descriptive in nature, lending itself to narrative forms of analyses, rather than statistical or comparatively quantifiable approaches. It can therefore be difficult to ascertain whether the case being investigated fits into a prototypical script or whether some elements of the script are incongruent. CSA, however, can nonetheless be used, much like traditionally more analogue forms of criminal investigative analysis, or "profiling", to prioritise suspects. An example can be used to underscore this added value of CSA: imagine a bombing has occurred in a busy public space. A crime script is developed wherein it is said that knowledge of bomb making is a necessary antecedent of the bombing attack. Next, the investigation turns to the suspects, of which there are two. The first has extensive experience with bomb making, as he has a military history and has worked in mining for a number of years. The second suspect has no history of bomb making, so clearly for him to be elevated by investigators to the level of "suspect", which has several procedural requirements beyond the scope of this discussion, he would have to find such information from online or offline sources. Therefore, Suspect One appears the more likely candidate; and yet, investigators are encouraged to look for online and offline behaviours of Suspect Two that may involve bomb-making learning practices. This sequential approach to understanding scripts can sometimes be missed in a general crime script, with larger encompassing scenes. Other timeline methods, however, are better suited to individual behavioural sequences, such as Behaviour Sequence Analysis.

Behaviour Sequence Analysis [23,24] is typically a *bottom-up*, data-driven approach to mapping timelines. While CSA takes crimes and develops scenes, in which behaviours are performed to attain or meet
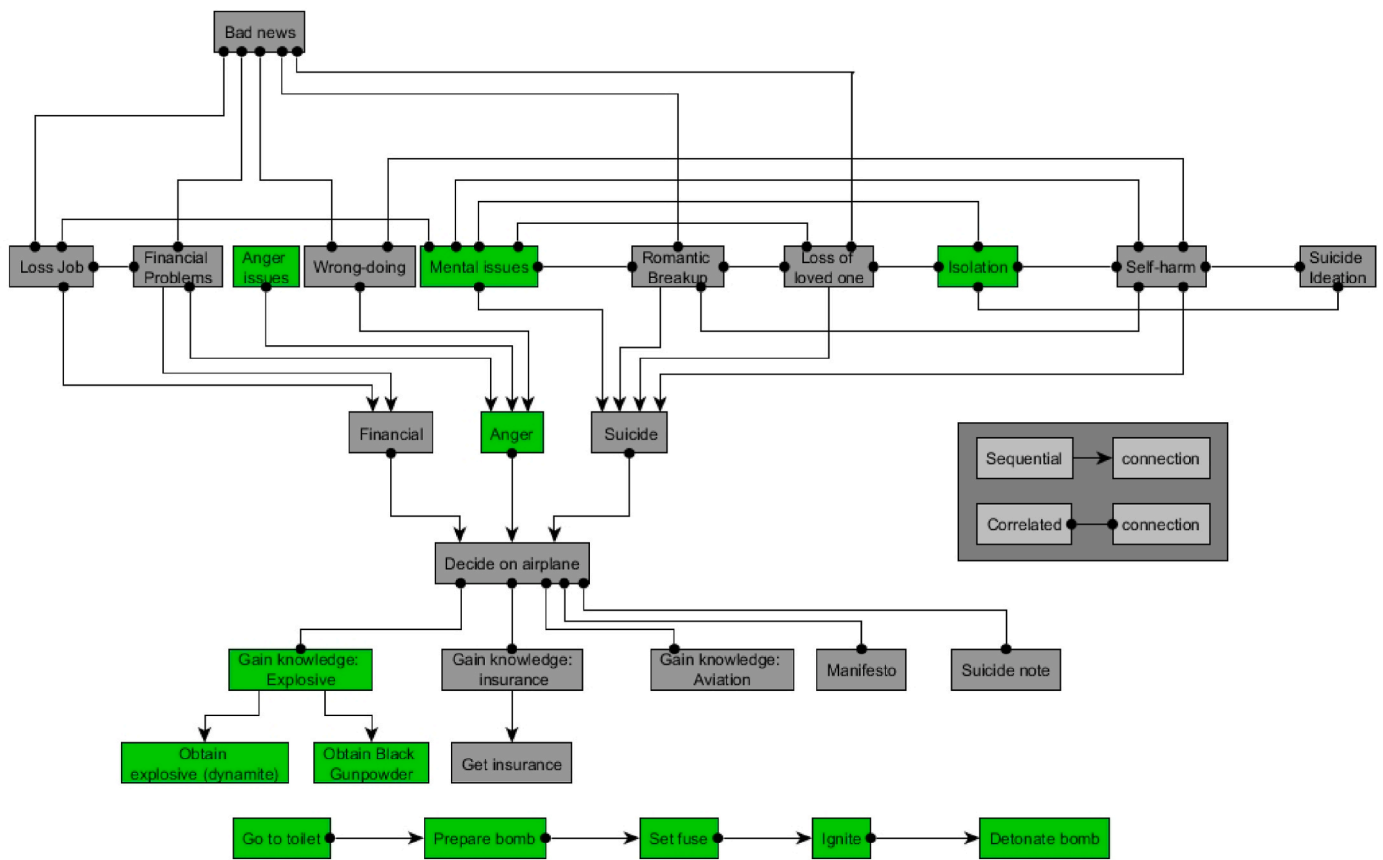
Fig. 4. Crime script sequencing for KOLESZAR

some goal of that scene, BSA instead maps sequential transitions of individual behaviours, events, emotions, and even cognitions. Essentially, while CSA may suggest behaviours *A*, *B*, and *C* occur within a certain scene, BSA puts these behaviours into sequential order: *A→B*, *B→C*. There are, of course, strengths and limitations to this more detailed, statistical approach to timeline analysis. First, while it does offer some numerical outputs in terms of the 'strength' of transitions (i.e., how likely they are to occur compared to chance); BSA requires detailed knowledge of individual transitions throughout the timeline. BSA lends itself very well to cases in which large quantities of very detailed sequences are available (e.g., CCTV footage, detailed diaries); however, in cold cases such information is typically unknown and/or unknowable.

Recently, researchers have attempted to develop methods to assist with cold case investigations, wherein information may be unknown and gaps in timelines extensive. The aim of the current paper is to provide a new method for analysing cold cases, that incorporates the strengths of both CSA and BSA. This method has been trialled against several open cold case investigations and has been shown to provide new investigative leads and discussion about key pieces of evidence in a case. These previously dormant cases that had been in abeyance prior to the application of CSS tactics are now offered new leads in active police investigations. Therefore, to highlight the added value of CSS to a cold case investigation, an openly documented case will be presented, one which similarly had the CSS method applied to it. The case will be outlined here, and the analyses and attendant discussion provided subsequently.

1.2. Canadian Pacific air lines flight 21

On July 8th, 1965, Canadian Pacific Airlines Flight 21 (CPA 21), a so-called "milk-run" commuter flight with multiple stops and brief layovers took-off from Vancouver, British Columbia, Canada with a final destination of Whitehorse in the Yukon Territory, a frontier town in the Canadian northern hinterland. Approximately 1 h after take-off, an explosion occurred in the rear left lavatory of the aircraft. This explosion led to the rear tail section of the plane detaching and the flight crashed at approximately 15:40, around 40 km west of 100 Mile House, British Columbia. All 46 passengers and 6 crew on board died in the crash. The police investigation eventually focused on 4 passengers as being potentially responsible for planting the bomb. No person has ever been publicly declared a suspect by police, nor have any charges been made. As of this writing, the case has still not been officially solved and remains open. The case remains the jurisdiction of the Royal Canadian Mounted Police (RCMP), which had at the time of the bombing—and retains—contracted front-line policing duties across much of rural Canada, including the area where CPA 21 came to ground. The aim of the current paper is not to 'solve' this case,[1] per se, but to evince how a combination of timeline methods may be used to re-investigate cold cases like this, wherein information is limited about the case itself. The combination of methodologies and expert perspectives will ideally yield new insight and investigative action items for police to pursue, as well as suspect prioritisation.

1.3. The suspects

Given that the bomb used in the CPA 21 cold case was placed in the

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[1] From first-hand experience working in larger cold case investigative societies and task forces, investigators are understandably sceptical of new methods that claim to be able to solve cases. There are no such magic bullets. Instead, most investigators are keen for a new method that opens new lines of investigation that they can explore. That is the goal of Crime Script Sequencing.
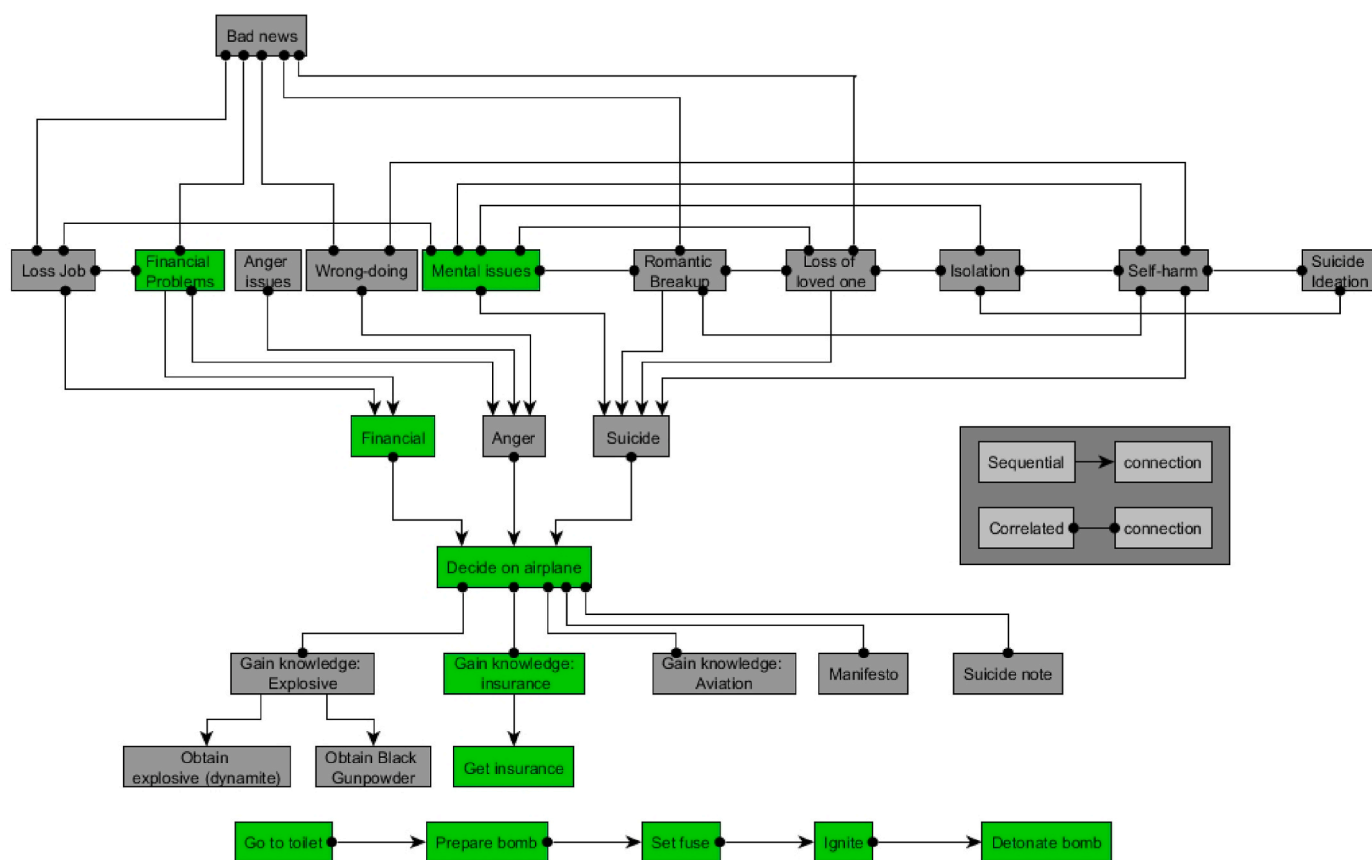
Fig. 5. Crime script sequencing for EDGAR

rear lavatory of the plane and detonated an hour after take-off—with an estimated 10-s delay from the time of ignition—investigators agreed that it was not placed onboard pre-take off. Interviews with the airline's cleaning crew and associated logs also confirmed that when the lavatory was cleaned pre-take-off, no package had been observed in the small space by staff who were cleared as suspects. Therefore, the suspect was agreed at the time—and now—to have been one of the 46 passengers or 6 crew onboard the flight. The original investigation was extensive, especially by the standards of the day, resulting in thousands of pages of detailed documents, statements, diagrams, laboratory reports, and other evidence. The investigation stalled, however, and though the 4 persons of interest were identified, no further evidence or information allowed the RCMP to officially resolve the matter to the satisfaction of its senior leadership. The four suspects will be outlined, without inference as to guilt or culpability.

Douglas EDGAR: an inveterate gambler who purchased a large quantity of life insurance immediately prior boarding the flight. He gave the insurance tickets to his daughters who were with him at the airport. The stated purpose for his taking the flight (a job opportunity at a remote lumber mill) was determined by police to be subterfuge. His purpose for being on the aircraft and his final destination remain a mystery.

Stefan KOLESZAR: an experienced miner with expertise in explosives and a military background. Koleszar also had multiple criminal convictions, including for manslaughter, and was dishonourably discharged from the military for sex offences.

Peter BROUGHTON: a young man at the time of the incident, described by those who knew him as a 'loner', with an interest in firearms and knowledge of gunpowder. He resided in a rooming house with his mother and had recently borrowed books on commercial aircraft, including the make and model of aircraft (Douglas DC 6B) operating as Flight 21 on the date of the explosion.

Paul VANDER MEULEN: An American entrepreneur described by his psychiatrist as having a "*deep madness toward the world*", he was confirmed to have been carrying a handgun and a large amount of cash on the flight after having opted to travel separately from the remainder of his entourage of prospectors headed to the Yukon Territory to explore mining opportunities.

Clearly, a compelling superficial case could be made for each of the 4 persons of interest outlined. The mere fact that these four individuals, given their backgrounds and idiosyncrasies, were on the same small aircraft is actually somewhat remarkable, even Hitchcockian [25]. Given the time that has elapsed since the bombing, it is, however, also unlikely that any new information will be found; thus, novel methods need to be developed to reanalyse existing evidence and perhaps shed new light on the case. That is the aim of Crime Script Sequencing (CSS), to bring together two leading timeline analysis methods and apply the combination to an unsolved cold case.

2. Methods

2.1. Sample

While there may not be new information available for CPA 21, there are other airline bombings that can be used to develop a script for such crimes—and which, in the context of cold cases, can be applied retroactively. This is typically one of the ways that Crime Script Analysis can be used to assist with an investigation. In the current study, 7 other acts of commercial aircraft bombing and sabotage with sufficient information about the bomb placement, suspects, and motives were used to develop a crime script for CPA 21. The cases were: United Airlines Flight 247 (1933); Philippine Air Lines PI-CP8 (1949); Canadian Pacific Flight 108 (1949); United Airlines Flight 629 (1955); Philippines Flight PR215
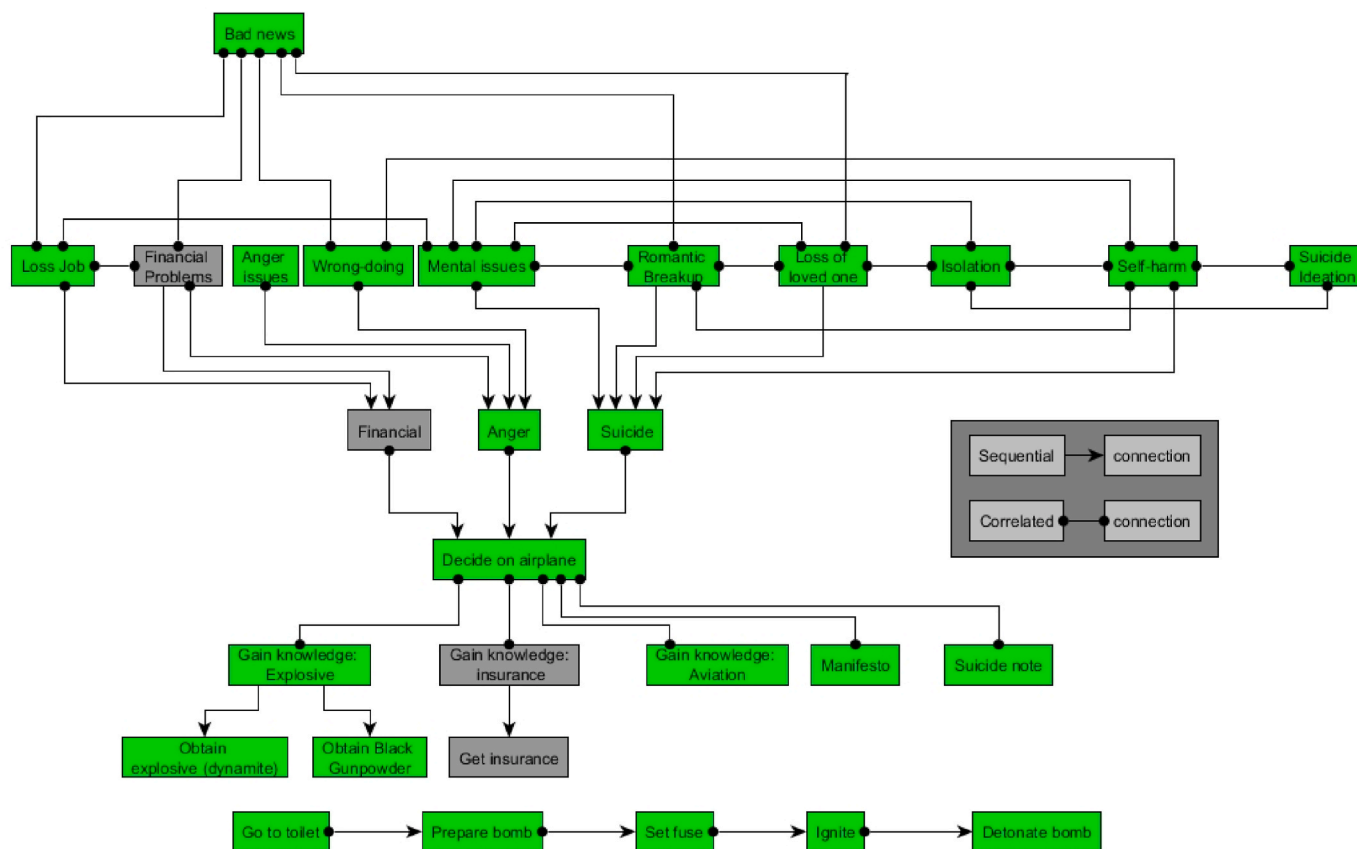
Fig. 6. Crime script sequencing for BROUGHTON

(1970); Philippines Flight BAC111 (1978); and American Airlines Flight 444 (1979). While this is not an extensive or exhaustive list of airline bombings, these are cases of mass murder, cases largely contemporaneous with CPA 21, that were found upon interdisciplinary review to have substantive, lengthy, and detailed procedural information available to clearly build a detailed script. The cases also imparted, for the purposes of this study, a variety of known or reasonably suspected motives and suspects responsible for the attacks. This data set therefore provided a comprehensive and compelling sample and representation of the multiple causes of and motives behind aircraft bombings during the mid-twentieth century for the purposes of developing scripts specific to the time. A strength of the CSA and BSA approaches are that if more cases are found, the database can be updated to see if and how the new cases affect the timeline. In this way, the methods are additive and positively integrate further data collection, rather than having to be completely re-analysed.

2.2. Script development

The details and evidence of each case in the sample were reviewed multiple times to ensure that the temporal information was clear and structured. Multiple secondary sources were used to corroborate information and include additional insights (e.g., police reports, court reports, and media reports[2]). The process of re-reading each case was to begin developing a script of the antecedent scenes leading-up to each bombing incident. One strength of any crime script approach to a cold case is the ability to mine and source information from a variety of

similar cases to identify the common characteristics of the script that connects each discrete criminal event. Scripts are then typically placed into a generalized timeline diagram [26] to allow for easier interpretation of how the script repeats itself across each iteration of the same crime—specifically, in this case, aircraft bombings that pre-date the era of political, ideological and religious terrorism now commonly associated with airline hijackings or bombings and which, by contrast, have no known or consistent motives.

3. Results & discussion

The current research developed an aircraft bomb construction-delivery-detonation script based on the previously tabled sample of cases. This script was then used as an archetype to which the current unsolved CPA 21 case could be compared.

Each of the cases were placed into sequential scenes in which several behaviours were performed. The *precipitators* scene outlined the general background life events and stressors that may be seen as a starting point on which offenders began their pathway toward pre-planned mass-casualty attacks on commercial aircraft. It demonstrates many factors that may affect the psychological disposition and feelings of such offenders. These precipitators were then found to lead to *motivations* of the perpetrators; these included without exception: *anger*, *financial*, and *suicidal*. An important part of developing the crime script is to highlight components of the re-investigation in which other experts may become involved. In developing the crime script for airline bombings, suicidality was noted as a motivation for several of the bombers in this study. There are, of course, world-leading academics whose expertise is in suicidal behaviours and suicidal ideation. Such experts were contacted for their input into the psychology and behaviour of suicidal individuals. This assisted the current study in constructing a more detailed, expert-driven analysis; it is also reinforced the interdisciplinary and collaborative

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[2] While this clearly does not guarantee veracity of information, it is an approved approach in Crime Script Analysis and provides as much information as police typically have available to them when re-opening cold cases.

nature of CSS as a new tool to be used in cold case investigations.

With respect to developing the next scenes in the bombing script, this study consulted experts in explosives in order to obtain their insight about actions and behaviours in these scenes. The next scene, *planning*, involved the active planning of how to actually create an improvised or homemade explosive device designed to down or destroy a commercial aircraft. Some offenders, it was determined, had apparent pre-existing expertise, while others needed to learn about bomb making through either—given the period in question—books or in-person tutelage. This is an area, as outlined above, that investigators can use to prioritise a suspect or potential relegate a suspect. *Instrumental initiation* involved the active planning and preparation of the plane bombing. This involves obtaining the materials and/or getting life insurance (for those motivated by financial means). The next phase of the crime script considered actions onboard the plane or how a bomb was otherwise planted on the plane. Of course, security protocols have changed significantly over the last few decades, so experts in aviation security from around the time were contacted to provide input on what would have been possible.

The crime script is developed with reference to various cases to highlight each scene and the behaviours therein. While this provides an elucidating account of plane bombings and perhaps even 'typical' plane bombings, it is hard to reduce this aggregate script back to an individual level. This is the ecological fallacy in effect, and it becomes hard to highlight which of the four persons in the CPA 21 case might be highlighted as a suspect. This ecological fallacy is not specific to crime script analysis, of course, but it does present a particular issue when attempting to use the method to progress a case. This is typically where investigators and practitioners may become frustrated by the method. Knowing the typical script is educational, applying it to an individual would be useful.

Given the relatively qualitative approach of CSA, analysing whether one of the four suspects in the CPA 21 case fits the script is a qualitative account of how closely they 'match' the prototype script developed. This can be informative and offer support for investigations but is lacks the numerical or statistical basis to provide much more than qualitative similarity statements. What is required, is a means of turning the CSA into a more numerical, statistical timeline, like BSA (see Fig. 1).

3.1. BSA

Many cold cases lack the clear sequential information required to conduct a BSA. While methods of matching BSA timelines exist, such as Behavioural Fingerprinting [5], without clear behavioural sequences to begin with, such methods are of little use. However, by integrated CSA with BSA, a middle ground can be achieved. In the case of CPA 21, the crime script was developed into a state transition diagram, the type commonly used in BSA [7]. Fig. 2 outlines the overall CSA developed into a type of *state transition diagram*, of the type commonly used in BSA. At this point, it is provided only to show how all of the behaviours within a CSA can be mapped as nodes in a diagram.

Fig. 2 shows every link within the CSA, some of which are sequential, while others may simply co-occur. This is the framework for plane bombings, and unlike a BSA, at this stage the connections do not denote 'strength' of connections between nodes. In BSA, lines connecting nodes typically indicate the standardised residual (SR) score, which is a measure of the association between antecedent and sequitur nodes compared to chance. Typically, thicker lines mean higher SR scores. These scores are analysed by looking at sequence strings (e.g., *ABCD; ABCE; ABCF*) and seeing how many times each pairing of behaviours (e. g., *A→B*) occurs, compared to chance. This makes for compelling and interesting Behaviour Sequence Analysis; but is of little use in a single cold case.

3.2. Integrating CSA with BSA

The first step to developing a more statistical approach to cold cases

is to mark the nodes in the diagram that each suspect 'highlights'. While by no means evidentiary in a legal setting, it provides an initial insight into the factors that feature in each suspect's profile. A benefit of this approach can be seen in the CPA 21 case. Each of the possible suspects highlighted a number of the nodes, indicating the reason why investigators listed them as a potential suspect. This helps clarify why cold cases are not often easily solved, as many individuals can be suspects based on a number of factors. More importantly, this approach can begin to highlight those suspects who have multiple nodes highlighted.

In the case of CPA 21, researchers and practitioners have focused on either the homicidal nature of the attack or the suicidal nature. It is one of the largest unsolved mass murder crimes committed in Canada - clearly pointing to an act of mass murder. The bomber, however, was a passenger on board, and therefore the act was also one of suicide. Though this is clear when highlighted, many profilers will typically lean towards one or the other and build a profile to support their views. One of the people highlighted by investigators, however, showed risk factors for both homicide and suicide motivations. This presents a new possibility for the profile: that both motivations were necessary for the bombing. Fig. 3 through 6 show the CSS for each of the suspects. What is immediately clear is that each of the suspects highlights several nodes, hence being a suspect. One suspect, however, highlighted a majority of the nodes.

In the CSA of airline bombings, several offenders placed explosive devices on commercial aircraft to kill others for an ideological motivation. Broughton is the only person in the CPA 21 case that appears to have both homicidal and suicidal antecedents. Briefly: Edgar showed no signs of being homicidal; indeed, his only potential motivation was to claim insurance money for his family. This singular motive qualified him as a suspect in terms of the financial motive, yet he demonstrated no signs or risk factors of being suicidal or homicidal. Koleszar, meanwhile, appeared to have some anger issues and predisposition to violence and some paraphilias; however, there was nothing suicidal noted in his past, and no known stressors in his life at the time of the bombing. Vander Meulen came under intense police scrutiny owing to his psychiatrist's report, which seemed to at least tacitly suggest a homicidal motivation, but again not suicidal. The point being: if the device had been placed on the aircraft without the bomber being on board, then homicidal motives would be a stronger factor to consider and would fit any number of other known scripts exhibited by set-and-run mass murderers relying on bombs. Owing to the bomber being on board CPA 21, however, suicidal motivations should also be considered—and prioritised in terms of script development. Of course, homicidal individuals can take their own lives as part of the crime commission, and suicide bombers are well-documented [27]. Many suicide bombers, however, stay with their bomb until detonation - which was not the case in the current plane bombing.

Broughton is the only suspect with corroborated indicators consistent with suicidality in his past. Broughton also had motive for being angry towards airlines and also had a confirmed recent acquired interest in and knowledge of airlines—including the specific make and model operated as CPA 21. In a simple additive model, Broughton is at the top of the suspect list, a fact noted by other authors [25]. This does not immediately mean Broughton is guilty. It does, however, offer new insights into the case and elevate him as a *suspect*.

3.3. Future steps: weighting nodes

A further level of analyses can be made to the CSS approach. Rather than simply highlighting the nodes and taking an additive model, researchers can begin weighting nodes in various ways. For example, in the current case, if the bomb were placed in luggage that was loaded onboard, then the anger and financial nodes could carry more weight - as these methods of bombing planes were typically seen in non-passengers who bombed planes for anger or financial motives. In the case of CPF-21, this would actually reduce Broughton's likelihood of

being the bomber and turn the focus to someone not on the plane.

Similarly, the type of explosives used can be used to weight certain suspects. Issues like how readily available the materials were and who had access to them could be used to elevate or relegate certain suspects. In the current case, Edgar did not have any explosives expertise or training, so his likelihood is diminished further if we weight the explosives nodes in terms of expertise and availability. Koleszar would immediately seem to be a more likely suspect, if the bomb matched those typically used in mining. The bomb used, however, did not require specialist knowledge, and colleagues' statements about Koleszar indicated he was a very safety conscious individual.

3.4. Future steps

The current method is not suggested as a solution to solving cold cases. The combination of CSA with BSA, however, has proven useful in cold case investigations by providing novel insights and investigative opportunities. While many academics think anything short of a complete solution and finger pointing firmly at one person is a failure, practitioners are often in need of something that can offer new insights. The current method positively endorses experts from various fields to parsimoniously work together and for their insights to be used to create clear scripts and diagrams. A further benefit of this approach is that as new information is discovered, from other cases or from investigation into the cold case, the diagrams can be updated. Sadly, many cold cases are not solved quickly, and often change-over in lead investigators occurs. A final benefit of the CSS method is that it provides a very quick, neat, succinct overview of the case, the suspects, and the progress made in narrowing down suspect lists.

4. Conclusion

Solving a cold case investigation is an extremely hard task. Cold case task forces and expert groups, while working diligently and tirelessly, still have a relatively low success rate. Academics from a range of disciplines can help with cold case investigations through developing novel techniques that can drive new lines of enquiry and add support to existing hypotheses. The current approach, Crime Script Sequencing, brings together two leading timeline analyses and offers a novel approach to building investigative leads from a range of expert opinions and data analyses. This approach has been used in several real-world cases and lead to positive feedback from practitioners owing to the clear pathways it produces and novel hypotheses it drives.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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