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CAN CCTV RELIABLY DETECT GUN CRIME?

Iain Darker,
Applied Vision Research
Centre,
University of
Loughborough,
Loughborough,
LE11 3UZ,
UK.

Alastair Gale,
Applied Vision Research
Centre,
University of
Loughborough,
Loughborough,
LE11 3UZ,
UK.

Leila Ward,
Applied Vision Research
Centre,
University of
Loughborough,
Loughborough,
LE11 3UZ,
UK.

Anastassia Blechko,
Applied Vision Research
Centre,
University of
Loughborough,
Loughborough,
LE11 3UZ,
UK.

Abstract - In recent years the highest levels of gun crime in England and Wales have been recorded. Gun crime is known to occur in environments that fall under the view of the networks of CCTV cameras which are endemic in urban Britain. Consequently, CCTV has the potential to detect gun crime. However, CCTV operators face a near impossible task: often, each individual operator is required to monitor multiple cameras for extended time periods. It is not surprising then to find that CCTV has had little effect at reducing gun crime. A new collaborative research programme (MEDUSA) is underway across the UK which will develop a software application to aid CCTV operators detect the precursors of gun crime. MEDUSA aims automatically to detect both guns as objects (concealed or otherwise) and people who intend to commit gun crime, via CCTV. The system is partly based on eliciting the features that skilled CCTV operators identify as indicative of a concealed weapon or suspicious behaviour related to gun crime. Initial studies into the examination of these skills across several CCTV centres indicate that there was little formal instruction in the detection of mal-intent. Much skill is built up from prolonged experience in examining CCTV imagery. Thus, potentially, there is widespread individualisation of detection skills. Further, visual cues specific to gun crime were limited. However, the present methodology relied upon direct report. It is argued that a range of both consciously and subconsciously detected cues could facilitate gun detection via CCTV. Future studies will examine this possibility.

Index terms - CCTV, visual inspection, gun crime.

INTRODUCTION

Firearms are taken to be involved in a crime if they are fired, used as a blunt instrument against a person, or used in a threat. Types of firearm include air weapons, imitation weapons, rifles, shotguns and handguns, as well as CS gas and pepper sprays [1]. Collectively, crimes involving firearms are referred to here as either firearms offences or gun crime.

The turn of the millennium has seen the highest levels of recorded firearms offences in England and Wales, with an all-time high of 24,094 offences recorded in the year ending 31st March 2004 [1]. Further, gun crime may be a greater problem than official figures suggest. The majority of firearms offences appear to occur within criminal circles, amongst whom the predilection for recourse to the law is likely to be low [2-4]. Thus, although crime in general is underreported, gun crime may be subject to a particularly high level of underreporting [3].

Gun crime in Britain is likely to have a complex, multi-faceted aetiology. It is possible to delineate two main types of gun crime: that which is instrumental and in which the gun is little more than a tool to facilitate an offence; and that in which the gun adopts a wider symbolic value [2-4]. The latter phenomenon relates to a more recently emerged, complex, criminal gun culture which has been associated with a number of factors: machismo; successful criminal role models; a lack of legitimate role models; drug markets; gang membership; the gun as a 'life-style' accessory and source of kudos; extreme materialism; poor legitimate employment opportunities; and social deprivation [2-6].

The complex criminal gun culture may represent a worrying social trend amongst certain sections of society in the UK. An increase in murder rates between 1981 and 2000, which was almost exclusively concentrated amongst young men who reside in the poorest wards of Britain, has been associated with increasing levels of social inequality [7]. Whilst compared to wealthier areas, these murders in the poorest wards were the least likely to involve firearms, the authors of that study note that the time period analysed largely excludes the explosion in gun crime since 2000. Given the factors associated with the new, complex, criminal gun culture, it is possible that gun-related murders are now concentrated amongst these same, underprivileged, young men whom society is failing. Ever increasing social inequality in the UK may, therefore, further exacerbate the problem of gun crime in the future.

Any ultimate solution to the problem of gun crime must deal with the difficult, societal issues which appear to fuel it.

However, this is likely to require arduous, long-term action. Consequently, there is also a need for more immediate measures which may prevent lives being lost while the underlying causes of gun crime are addressed. One possible, technological, and cost-effective approach is to utilise the widespread and endemic installation of CCTV cameras in Britain.

Can CCTV reliably detect gun crime? CCTV networks surveil public spaces in town and city centres, and on housing estates [8]. Instrumental gun crime can involve high-street business premises and street robbery, whilst complex gun crime may additionally tend to involve drug markets at street-level, as well as night clubs and other music venues [2-4]. Thus, the types of areas covered by CCTV networks could, potentially, allow CCTV to target aspects of both instrumental and complex gun crime. Further, CCTV operators are able to predict [9] and proactively search out [10] lawless behaviour. Thus, given the combination of a suitably distributed network of sensors and sensitivity to the signal in question, it would appear that CCTV can offer at least part of the solution to the problem of gun crime.

However, a number of factors conspire against CCTV operators in their efforts to proactively detect crime: a single operator is required to monitor the live feeds from tens to hundreds of cameras [8]; the amount of time during which vigilance can be effectively maintained is limited to about an hour [11], whilst working hours far exceed this threshold [8]; the ability of a person to spot suspicious behaviour is fallible [9]; assignments of suspicion can be based on little more than personal prejudices [10]; and boredom or prurience may induce operators to indulge in activities outside of their job description [10, 12]. With respect to gun crime, the problem may be compounded by the fact that such crimes are relatively rare in comparison to other events observed via CCTV. This offers CCTV operators little opportunity to learn the indicators of gun crime.

It is not surprising then to find that empirical studies indicate that CCTV has not had a significant impact in reducing crime [13]. With regard to gun crime, whilst there is no evidence relating specifically to the impact of CCTV on gun crime, there is no evidence to suggest that CCTV is reducing gun crime at present; it has already been noted that the levels of gun crime in Britain are high in historical terms. However, issues relating to the detection of crime are not necessarily wholly responsible for the apparent lack of crime reduction following CCTV installation. For CCTV to be effective the responses of various law enforcement agencies to the detection of a crime, as well as the manner in which the Criminal Justice System handles those brought before it, must also be effective. It is noted that conviction rates for gun crime are exceptionally low, at least in certain areas [2]. Even so, it is suggested that failures of detection contribute significantly to the problem. The factors which restrict the utility of CCTV in the detection of gun crime appear to relate to limits placed on CCTV surveillance by human factors. They can be summarised as limits on the capacity of a small number of CCTV operators to proactively monitor many camera feeds for extended periods, and a

potential lack of ability to recognise gun crime given its relative rarity.

Thus, at present it appears that CCTV cannot reliably detect gun crime. However, automated, intelligent CCTV systems can circumvent problems associated with human-mediated surveillance [14]. These technologies are now capable of performing complex, automated, real-time analyses [15-19]. Currently, none specifically address the issue of gun crime. MEDUSA (Multi Environment Deployable Universal Software Application: see www.medusacrime.org) aims to bring the advantages of automated, intelligent CCTV systems to bear upon the problem of gun crime and improve the reliability with which gun crime is detected [20].

With regard to increasing the capacity for proactive surveillance (both in terms of the number of feeds and duration of monitoring), an automatic system has clear advantages. Given adequate bandwidth and processing power, MEDUSA could automatically analyse the live feeds from cameras in a public CCTV surveillance network for visual signs of gun crime and its precursors. Where a gun crime event is detected, the CCTV operator would then be alerted; the operator would be afforded the opportunity to act upon events that would not otherwise have been brought to his or her attention. Thus, MEDUSA could shoulder the burden of monitoring multiple cameras and maintaining vigilance for extended periods.

However, this capacity for proactive surveillance would only be useful if MEDUSA were sensitive to CCTV-mediated signals that indicate gun crime. The potential for digital image processing software like MEDUSA to recognise and detect gun crime has yet to be fully established. Thus, it is necessary to determine visual cues that are both specific to gun crime and conveyed via CCTV. Research is underway to derive two sets of such cues: machine-derived cues; and human-derived cues.

Machine-derived cues consider the latest digital image processing algorithms in object detection, motion tracking, and machine learning. An extensive database of both real-life and staged gun crime footage is being accumulated and these algorithms will be used in comparisons between footage of gun crime and appropriate control scenes. It is planned that these comparisons will reveal both static and dynamic precursor cues to gun crime.

The human-derived cues will be determined by empirical, psychological experiment. The wealth of expertise that CCTV operators, other professionals, and even everyday people have at recognising specific objects and behaviours are being exploited. For instance, it has already been noted that the occurrence of crime can be predicted via CCTV, on the basis of visual information alone [9, 10]. Once elucidated, these machine- and human-derived sets of cues will be merged in an empirically determined, optimum combination.

The present study is an initial investigation into the nature of human-derived visual cues to gun crime. Training provision to aid CCTV operators in the proactive detection of mal-intent was investigated in order to determine the visual cues that CCTV operators are instructed to use in the proactive detection of crime. This involved a consideration of two sources of training: a Security Industry Authority (SIA) licensed training course

(which, from March 2006, became compulsory for all Public Space Surveillance CCTV operators in the UK); and in-house training which is specific to individual CCTV control rooms. Additionally, CCTV operators and CCTV control room managers were interviewed regarding the use of visual cues, in practise, in the proactive detection of mal-intent. In the event that a CCTV operator had proactively detected gun crime, detailed information about the event and the reason for monitoring that event was solicited. Where possible, CCTV footage of the event was reviewed. An attempt was made to qualitatively catalogue any visual cues that CCTV operators used to proactively spot mal-intent, and especially gun crime, via CCTV. The level of detail given in the methodology, results, and discussion sections is designed to convey the findings of the study without identifying an individual SIA Public Space Surveillance training program provider, CCTV control room, event, or person.

METHODOLOGY

One SIA accredited CCTV operator training course and four CCTV control rooms with Public Area Surveillance Systems were surveyed between June 2005 and December 2006. The control rooms were under varying combinations of local authority and local police authority control. Centre A was situated in a town with a population of approximately 150,000. Two CCTV operators were responsible for monitoring 31 public space CCTV cameras via 24 CCTV monitors. Twenty-four-hour surveillance was not provided. Centre B was situated in a city with a population of approximately 200,000. Three CCTV operators were responsible for monitoring 172 public space CCTV cameras via 20 CCTV monitors. Twenty-four-hour surveillance was provided. Centre C was situated in a city with a population of approximately 250,000. Eight CCTV operators were responsible for monitoring 199 public space CCTV cameras via 30 CCTV monitors. Twenty-four-hour surveillance was provided. Finally, Centre D was situated in a city with a population of approximately 450,000. Five CCTV operators were responsible for monitoring 240 public space CCTV cameras via 60 CCTV monitors. Again, twenty-four-hour surveillance was provided.

Training Provision

An SIA CCTV training course was attended and examined for content on detecting suspicious behaviour. The specific intention was to catalogue the visual cues to mal-intent and crime that CCTV operators are instructed to proactively search for. Additionally, CCTV control room managers ($n = 4$), one from each control room, participated in an unstructured interview which addressed various predetermined themes. Of relevance here, in-house training provision in the CCTV-mediated detection of mal-intent and crime was examined.

Visual Cues to Mal-intent

Visual Cues to mal-intent, crime, and especially gun crime were investigated. CCTV operators ($n = 8$, some of whom were also CCTV control room managers) were interviewed to solicit any visual cues to mal-intent and crime that they utilise when proactively searching for such occurrences. Where gun crime had been proactively detected, the cues used in the detection were examined further ($n = 2$). Five such instances of proactively detected gun crime were uncovered. For four instances of gun crime detected by one CCTV operator it was possible to review the CCTV footage leading up to the detection and so verify the CCTV operator's version of the events. The following are reported for each of these five instances of gun crime: reasons for initially targeting the incident; reasons for inspecting the incident further; reasons for suspecting the involvement of a firearm. Only cues that the CCTV operator reported using in the detection of the gun crime are reported. An exhaustive account of all the cues present in each clip is the subject of further investigation.

RESULTS

Training Provision

The SIA Training Course: The SIA training course extended to 30 hours over four days. The subject matter encompassed principally the technical, legal, procedural, and forensic necessities involved in using CCTV. However, one hour of the course was dedicated to reading body language and spotting mal-intent. Various visual cues and their significances were highlighted. These included visible signs of negative affect. For instance, the crossing of arms or legs was defined as a defensive gesture, whilst the narrowing of the eyes, with the head tilted back and to the side, and with lips tightly together was cited as an oft given sign of hatred or dislike. Also highlighted was the need to watch out for occurrences that are out of the ordinary in a situational context. One example related to the wearing of clothes which differ from expectations: wearing a heavy coat or jacket when everyone else is wearing T-shirts. Additionally, specific behaviours were deemed suspicious. For instance, constantly looking around, or continually returning to one particular location. The use of these cues as indicators of mal-intent or crime was balanced against alternative explanations including that a person may be lost, confused or ill.

This theory based lecture on body language was supplemented by an activity in which it was necessary to assess, using a multiple choice format, the emotional states of various people who were depicted on a handout. Also, an illustrated summary handout of body language and its meanings was given as a reference for study later.

In-house Training: Formal in-house training typically dealt with technical, operational, legal, and forensic issues. It did not cover spotting mal-intent or detecting crime.

“... our training pack deals with how to use the equipment and governing legislation, we also

have a training session on forensic awareness. Suspicious behaviour be it gun crime or other crime is pretty much down to the individual's insight or gut feeling, I would suspect that comes only from experience." - CCTV control room manager.

Training in spotting suspicious behaviour and proactively searching out crime, where present, was informal.

"I tell them look out for trends in the different areas, to make themselves familiar with what usually goes on in the different areas at different times, so they will be able to spot when something out of the ordinary goes on." - CCTV control room manager.

Typically, it was left to the individual operator to accrue experience and, where possible, draw on prior experience in order to develop the abilities to spot suspicious behaviour and proactively search out crime, via CCTV.

"... it takes about 12 months for an operator to learn what is normal for the different areas, and so become competent." - CCTV control room manager.

"... the best operators have previously been store guards because they have lots of experience monitoring people's behaviour, so will be able to identify suspicious behaviour quicker." - CCTV control room manager.

The lack of a prescribed training programme for spotting mal-intent may lead to wide variability in the development of skills in this area.

"A number of the operators are particularly good at the proactive work, some are not so good." - CCTV control room manager.

Visual Cues to Mal-intent

Visual cues to general mal-intent and crime: The visual cues that CCTV operators reported using in spotting mal-intent can be divided into three categories: cues relating to certain high-risk groups; cues identifying specific individuals; and generic situational cues.

High risk groups: Indicators of groups considered at a high risk of committing crime were described.

"...drug addicts walk like zombies ... they look gaunt..." - CCTV operator.

"...people of working or school age who just hang around the [...] centre all day..." - CCTV operator.

"...some people, especially those up to no good, will try and avoid the cameras and act like they are aware of them; they'll turn away etcetera, most other people will act like the cameras are not there." - CCTV operator.

Specific individuals: CCTV operators also reported recognising specific, known criminals. Although the cues used in these recognitions were not greatly elaborated upon, there was a suggestion that an individual could not only be

recognised facially, but that their behaviour and gait could also be used to identify them.

"...you get to know the local trouble-makers." - CCTV operator.

"You can recognise people from many different things- not just a good facial picture, from behaviour, gait." - CCTV control room manager.

"Experienced police and operators are very good at recognising people, even if they are far away or the image is poor, they may still be able to identify from gait or behaviour." - CCTV control room manager

Generic situational cues: Additionally, the use of generic situational cues was described in terms of spotting situations that are considered abnormal in a given context.

"...look for things out of the norm for the area, time of day, season..." - CCTV control room manager.

Cues used in the proactive detection of gun crime: Amongst the CCTV operators interviewed, two had proactively detected gun crime. One operator had detected four instances of gun crime, the footage of these instances was reviewed (see instances one to four, below). The other operator had detected one instance of gun crime, the footage of which was not available (see instance five, below).

Instance 1: The CCTV operator zoomed in on a group of four young boys aged approximately 12 to 13 years. They were making their way along a busy, peripheral shopping street in the middle of the day, each with a small, blue plastic bag in hand. Two of the boys hurriedly crossed the road in front of slow moving traffic, clumsily jumping pedestrian safety barriers. Whilst crossing the road, one of these two boys briefly removed what appeared to be a BB gun from the rear of his waistband. The gun had been concealed beneath his hooded top. He then quickly replaced it. Once across the road, these two boys loitered, looked about warily, and surreptitiously unpacked another BB gun which the other boy had hidden in the front pocket of his jacket.

Reasons for targeting: group of young boys in hoodies and track suits, unaccompanied in the middle of the day.

Reasons for further inspection: furtive behaviour when crossing the street; the brief sighting of a gun.

Reasons for suspecting the involvement of a firearm: gun spotted.

Instance 2: The CCTV operator sequentially zoomed in on a number of people who were on a main shopping street at the start of the working day, inspecting each person briefly. The CCTV operator then proceeded to zoom in on a lone gentleman. This lone gentleman was approximately fifty years old and was wearing a leather jacket and jeans. He was walking with a crutch, had a noticeable limp, and exhibited signs of a systemic movement disorder. In his left hand he held what appeared to be a handgun which was wrapped tightly in a black bin liner. The CCTV operator zoomed in on the item to confirm the suspicion.

Reasons for targeting: sweep of each individual in the street; conspicuous walking movements.

Reasons for further inspection: the sighting of a gun shaped object tightly wrapped in a bin liner.

Reasons for suspecting the involvement of a firearm: the shape of a gun was apparent through the plastic bag.

Instance 3: The CCTV operator zoomed in on a group of four, 12 to 13 year old boys who were huddled together on benches in an otherwise deserted public park, in the early afternoon. They appeared to be “skinning up” and they were looking around warily. After a few minutes a hand held machine gun became visible, it was being passed around the group. The ease with which it was handled suggested that it was a light-weight, plastic imitation.

Reasons for targeting: a group of young boys in hooded tops; local crime hot spot for drug taking.

Reasons for further inspection: the huddled nature of the assembly; drug taking behaviour.

Reasons for suspecting the involvement of a firearm: gun spotted.

Instance 4: The operator used the PTZ functions of a CCTV camera to follow a young woman in “clubbing” clothes. She was walking alone, along a street, in the early hours of the morning. A young man appeared at the other end of the street and approached her, purposefully. They gestured to each other as they drew closer. When he was upon her, he quickly drew a handgun from the front of his waistband. The gun had been concealed under his leather jacket. He held it to her head and then, in an instant, concealed it again.

Reasons for targeting: a lone female on the street in the early hours of the morning.

Reasons for further inspection: the CCTV operator was “walking” the young lady home; the approaching young man; the aggressive stance of the young man.

Reasons for suspecting the involvement of a firearm: gun spotted.

Instance 5: The CCTV operator was cycling through camera views and noticed a car which was parked at a closed-down garage. The driver opened the car window and hung his arms out of the window. He was holding a shotgun in plain view. The driver then drew the gun back into the car and drove off.

Reasons for targeting: the CCTV operator was proactively cycling through camera views.

Reasons for further inspection: the car was parked in a place where there would not normally be a car.

Reasons for suspecting the involvement of a firearm: gun spotted.

IV. DISCUSSION

In this initial investigation of the nature of CCTV-mediated visual cues to gun crime, visual cues to mal-intent that CCTV operators are trained to use and visual cues to mal-intent that CCTV operators report utilising have been identified.

With regard to formal training in the proactive detection of mal-intent, as a bare minimum CCTV operators attend an SIA accredited training course. As part of an intensive 30-hour learning package, the detection of mal-intent via CCTV is concentrated upon for an hour. The cues made explicit here are those relating to visible signs of negative affect, those indicating that something is out of the ordinary in a situational context, and particular behaviours which are indicative of mal-intent. None relate specifically to gun crime. In-house training in the detection of mal-intent was informal. CCTV operators were directed to learn what was normal for a given area at a particular time and to look for anomalies, sometimes guidance was given. Again, the issue of gun crime was not specifically addressed in training.

Thus, there is seemingly little formal training in visual cues to mal-intent and no formal training with respect to the detection of gun crime. This is despite the fact that training guidelines for CCTV operators emphasise the need for them proactively to spot crime in order to be effective [21]. The learning of visual cues to mal-intent is primarily based on a combination of on-the-job experience and adaptation of prior experience. Therefore, it might be suggested that the nature of the various cues used in detecting mal-intent could show much variation across individuals. Based on reports from CCTV operators these cues can be summarised as: cues identifying high risk groups; cues that identify specific, known criminals; and generic situational cues relating to anomalies or occurrences that are out of the ordinary. The use of situational cues and the targeting of presumed high-risk groups have been noted in prior research [10]. None of these informally learnt cues related specifically to gun crime.

Even where gun crime was detected proactively, the visual cues or CCTV operator activities which led to the detection did not appear to be specific to gun crime. The CCTV operator did not target the event or individual because gun crime was suspected. CCTV operator activities that resulted in gun crime detections included a sweep of people in a street, cycling through camera views, checking crime hot spots, and ‘walking’ a vulnerable person home. Visual cues that caused CCTV operators to begin monitoring the event that resulted in a gun crime included visual identifiers of high risk groups (e.g., groups of unaccompanied young boys), conspicuous individuals (e.g., a man with a movement disorder), and out of the ordinary occurrences (e.g., a car at a closed-down garage).

This initial study is too small to draw conclusions about the utility of specific cues in the detection of gun crime. However, each of the observations collected here indicates that where gun crime has been detected proactively, the CCTV operator was monitoring the event for a reason other than the specific suspicion of gun crime. In each case the fact of a gun crime became apparent only when the gun was in view or when the shape of the gun was readily discernible.

Thus, the initial indication is that CCTV operators report little that is specific to gun crime in the early stages of the detection process. The shape of the gun itself may well be the first cue which specifies a gun crime. However, this study is an initial, small-scale, exploratory investigation. It is neither a

comprehensive, nor in depth consideration of all potential human-derived visual cues to gun crime. The work relied upon the direct report of visual cues as a knowledge elicitation technique. Therefore, it can only reveal cues to the intention to commit gun crime that CCTV operators are overtly aware of using and which they can verbalise. It is likely that, when determining the intentions of those viewed via CCTV, CCTV operators also use cues that they are unaware of and which they cannot verbalise. For instance, the participation of both cognitive [22] and perceptual [23] elements in determining intention have been posited. Within the human visuo-cognitive system, cognitive elements may tend to operate at a conscious level, while perceptual elements may tend to operate at a subconscious level. This raises the possibility of overt and covert cues to the intention to commit gun crime. Indeed, it has been shown that experts and novices are equally adept at predicting whether something "bad" will happen when shown real-life CCTV footage of the events leading up to a lawless act [9]. This might indicate both that visual, behavioural cues to mal-intent may operate at a perceptual level and that they are detectable via CCTV; these findings might extend to the intention to commit gun crime. MEDUSA is unique in considering the use of such covert cues in the design of image analysis algorithms to automate CCTV-based event detection.

It is possible to speculate upon the nature of visual precursors to gun crime. For instance, in this study CCTV operators reported being able to spot a gun when it was in plain view. The potential value of using CCTV to spot a gun in plain view should not be underestimated, particularly if it is possible to identify the type of gun. Different types of gun are associated with different uses and different types of offender [3, 4]. Therefore, this information may be very useful to the agencies dealing directly with a firearms incident, particularly if the gun is not visible from their perspective. There is potential for identifying the type of firearm via CCTV as firearms vary widely with regard to form and operation [24].

Further, carrying a gun may have direct, physical consequences which could be apparent via CCTV. These might relate to the shape, size, and weight of the gun in relation to its effect upon clothing and attempts to conceal the weapon. This study noted an incident in which a gun was detected as a result of its shape being apparent through a black, plastic bag. The gun may also have an effect upon gait, stance, or posture. Indeed, movement cues associated with gait may be incredibly informative; it is possible that they can even reveal information about individual identity [25].

Another manner of visual cue to gun crime could relate to the typical profiles of the perpetrators of gun crime in relation to the spatial and temporal distributions of gun crime. For instance, gun crime is typically perpetrated by men of certain demographic groups, the profiles of whom vary by local environment, regional area, time of day, and time of year [2-5]. All of these factors could be derived via CCTV on the basis of known camera location, known time and date, and the visual characteristics of the appropriate demographic. However, such cues may not be definitive. It is unlikely that an appreciable portion of a given demographic, at a given time and place, will

be gun criminals. Additionally, it has been noted that gun criminals can have other, often younger, people carry their guns for them in order to displace the risk of getting caught in possession of a gun [4]. These individuals may differ systematically from those who typically commit gun crime in terms of parameters other than age. For instance, they could be female.

Visible, behavioural indicators of the intention to commit gun crime may offer another gun crime signal which could be conveyed via CCTV. Further, these behavioural cues could be specific to the intention to commit gun crime. It has been shown that weapons can prime aggressive behaviour, via semantic association [26, 27]. Importantly, such behaviour patterns may be stimulus and context specific, stereotyped, and automatic to some degree [28, 29]. Therefore, specific behaviour patterns may exist for a given type of gun, in a given context. They may also mark specific intentions, offering the potential to distinguish between the intention to kill and the intention to intimidate.

Alongside the induction of specific behavioural patterns, guns may also evoke certain feelings. These feelings may have visible, physiological and behavioural markers which could be conveyed via CCTV. For instance, guns have been found to elicit aggressive emotional states [27, 28]. Additionally, a survey of convicted gun criminals noted that some experienced feelings of empowerment, fear, or exhilaration in relation to carrying guns, although others described being indifferent to gun carrying, particularly when gun carrying was routine [4]. Feelings like fear, aggression, and excitement have visible, physiological and behavioural markers. Whilst it is perhaps unlikely that these markers will be definitive of gun crime, in conjunction with other cues their presence or absence may indicate the level of experience of the gun criminal.

Each individual source of visual cues is likely to have considerable limitations. However, taken together they may have significant predictive power and may offer a rich source of information about the perpetrator and the weapon. Of particular interest may be the potential to distinguish between a criminal who intends to kill and one who will use a firearm only in threat, or the potential to distinguish between an imitation firearm and one that is lethal barrelled. Future studies will investigate the existence of these various sources of visual cues to gun crime at both overt and covert levels, and assess their predictive power alone and in combination.

CONCLUSION

Can CCTV reliably detect gun crime? Britain has CCTV coverage which overlaps with the types of location in which gun crime may occur. Additionally, this study has noted instances in which guns have been detected via CCTV, by human CCTV operators. Thus, the detection of gun crime via CCTV is certainly possible. However, human-mediated CCTV surveillance has not reduced overall crime rates and, particularly, gun crime is at an all-time high. A number of factors which hamper human-mediated CCTV surveillance have been noted, these relate to a limited capacity for proactive monitoring and fallibility in recognising crime. Reliable gun

crime detection would require indefatigable and ubiquitous proactive monitoring in combination with infallible recognition of gun crime. This might only be achieved through automation of the detection process. Thus currently, CCTV cannot be said to detect gun crime reliably.

The present study addressed the elucidation of human-based visual cues for incorporation into an automatic, CCTV-based, gun crime detection system (MEDUSA). The reliability of this system would, in part, rest upon making such visual cues explicit in order that they can be operationalized in its image processing algorithms. Besides the gun itself, this study has not elicited cues that are specific to gun crime itself. The detection of the gun itself could be fruitful in the development of a reliable gun detection system, but such a strategy may, in many circumstances, offer little opportunity for the appropriate agencies to intervene. Thus, whilst a system which spotted the gun might reliably detect gun crime, the utility of this system may be limited.

The present study has not revealed a wider range of visual cues to gun crime and this may well reflect both its small-scale and the methodology adopted; as opposed to the non-existence of further, human identifiable cues to gun crime. A body of literature indicates the potential for a number of cues which may be utilised by CCTV operators in spotting gun crime and which could be exploited by an automatic system. The potential cues reviewed here could highlight the gun criminal long prior to the crime and irrespective of the visibility of the gun, perhaps through behavioural analysis. Further investigation is necessary, but assuming the existence of such cues it is conceivable that an automatic CCTV system can be derived which will detect gun crime in a robust, timely, and useful fashion.

Taking a wider perspective, simply improving the detection of gun crime may have little influence upon its occurrence. In general terms, to effect a reduction in crime the probability of detection must be high and detection must lead to serious consequences for the criminals involved [30]. If carrying a gun was associated with near certain detection and punishment, then it is likely that gun carrying would be deterred. Further, an effective deterrent to the carrying of guns illegally could have compounded benefits by inducing a 'firebreak' effect [2]: many of those who carry guns do so for protection [4, 5], thus, a general reduction in gun carrying would reduce the imperative to carry a gun for protection. Therefore, when coupled to appropriate action, MEDUSA may be able to go beyond reliable gun detection to significantly reduce gun crime.

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VITA

Iain Darker graduated from Nottingham University, England, with a BSc in neuroscience and a PhD in cognitive psychology. He is a member of the Institute of Engineering and Technology and the Applied Vision Association. Since 2006 Iain has been a Research Associate on the MEDUSA project.

Alastair Gale graduated from the University of Durham, England, with a BSc and a PhD in psychology. He is a Fellow of the British Psychological Society, a Chartered Psychologist and Health Psychologist, a Registered Ergonomist, and a Fellow of the Ergonomics Society. He is also an honorary member of the Royal College of Radiologists' Breast Group and was awarded honorary membership of the Royal College of Radiologists in 1998 for his radiological research. Alastair has been Professor of Applied Vision Sciences at Loughborough University, England, since 2005.

Anastassia Blechko graduated from the University of Amsterdam, Holland, in 2001 with an MA degree in cognitive psychology. She is a member of the European Chapter of the Human Factors and Ergonomics Society, the Dutch Association for Psychonomy, and the Applied Vision Association. Since 2006 Anastassia has been a Research Student allied to the MEDUSA project.

Leila Ward graduated from the University of Loughborough, England, in 2006 with a BSc degree in ergonomics. Leila worked as a researcher on the MEDUSA project between 2006 and 2007.