The (Change) Blindingly Obvious:
Investigating Fixation Behaviour and Memory Recall during CCTV Observation

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The thesis is submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy of the University of Portsmouth.

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“Yes, Big Brother is watching you. But for a good reason”

Judd, 2013
General Abstract

Relatively little is known about the strategies that people use when monitoring and interpreting (criminal) events observed in CCTV footage. Four studies reported in this thesis used a change blindness task to explore: (a) whether instructions and/or event type influence where people attend to during CCTV observation; (b) how factors such as task instructions and central and marginal information influence fixation behaviour during CCTV observation; (c) the effect of change detection on memory recall during CCTV observation; and (d) whether verbalisation, attentional set and/or repeated viewing improve change detection and memory recall rates for CCTV footage. In Experiment one, we found that change detectors fixated on the changing target directly before the change more so than non-detectors. We replicated this finding in Experiment two and additionally found that change detectors, more so than non-detectors, produced significantly more and longer fixations on the change target during the change. The findings from Experiments one and two demonstrated that observers were drawn to a criminal event, more so than a non-criminal event, and that this was especially the case for central rather than marginal events in the footage. We found no evidence that instructions significantly affected gaze behaviour. In Experiment three, we found that change detectors recalled more accurate detail from the CCTV footage compared to the non-detectors, but only once the severity of the crime had increased. Experiment four found improved rates of change detection during CCTV observation when participants were able to repeatedly view the footage. Verbalisation (thinking aloud) however made no difference in terms of change detection and the accuracy of memory recall. These findings may help to inform training courses aimed at instructing people how to optimally attend to CCTV footage.
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Declaration

Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of the named candidate and have not been submitted for any other academic award.

Gemma Graham

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Abbreviations

CCTV………………………………………………………Closed-Circuit Television

CB…………………………………………………………….Change Blindness

IB……………………………………………………………..Inattentional Blindness
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I would like to dedicate this thesis to my Mum.
Dissemination

Publications


Conference and Invited Speaker Presentations


Chapter 1: General Introduction to Thesis
1.1 Introduction

On the 12th February 1992 at the New Strand Shopping Centre in Bootle, two year old James Bulger was walking through the shops holding the hand of a ten year old, Jon Venables. The moment was captured on a Closed Circuit Television Camera (CCTV) and remains one of the most recognisable and haunting CCTV images of the last few decades. Jon Venables and his friend, Robert Thompson subsequently went on to murder James Bulger. This criminal case became one of the first in the United Kingdom that used CCTV images to appeal to the public for information. Although CCTV did not stop the incident occurring, these images were replayed night after night on the national news and aided in the identification of the perpetrators (Norris, McCahill & Wood, 2004).

Although CCTV footage is used for both crime prevention and police investigations, relatively little is known about the strategies that observers use when monitoring and interpreting (criminal) events observed in such footage. The complexity of the constantly changing scenes often encountered when viewing CCTV footage highlights an important and applicable context in which real-world, fast moving environments need to be visually understood. The limited research available has found that both expert CCTV operators and psychology students are able to predict the onset of criminal behaviour by focusing on the behaviour (body position and gestures) of the people in the footage (Troscianko, Holmes, Stillman, Mirmehdi, Wright, & Wilson, 2004). Similarly, Howard, Gilchrist, Troscianko, Behera and Hogg (2011) found that when observers had to monitor multiple displays, they allocated their gaze more frequently towards suspicious behaviour rather than other aspects of the footage. Therefore, observers’ attention may be drawn to specific aspects of CCTV footage as they are trying to comprehend the event that is unfolding in front of them. This previous research highlights that participants will allocate their attention to
scenes systematically either in an attempt to understand what is taking place in the footage (i.e. observing non-verbal cues such as body position) or based on task goals and instructions (i.e. attending to areas of suspicious behaviour on CCTV footage when instructed to detect criminal behaviour). The research in this thesis will explore this further using stimuli and experimental conditions that reflect real-world situations faced by CCTV operators in both live and post-event tasks.

Observing CCTV footage can place a huge demand on the visual system and psychological research has powerfully demonstrated that our perceptual systems can fail to spot changes in the environment (Scott-Brown & Cronin, 2007). This phenomenon is called change blindness and refers to an inability to detect changes in our perceptual environment from one view to the next (Levin & Simons, 1997). By necessity, a CCTV system must flick between multiple views of a complex scene to try to capture as much information as possible. Therefore, the average CCTV system can be considered a ‘change blindness’ machine, leading to the possibility that crucial information may be missed (Scott-Brown & Cronin, 2007). Nevertheless, there are some people who do detect these changes (see Levin & Simons, 1997). Despite this, there has been little research investigating the visual strategies of change detectors and non-detectors. This research is important as we know very little regarding what differentiates those who detect changes from those who fail to detect them.

The experiments in this thesis will use an applied change detection task in order to understand attentional processes when observing CCTV footage. Experiments 1 and 2 implemented eye tracking technology to investigate attentional and cognitive processes during CCTV observation for those who do and do not detect changes. The recording of eye movements during observation of natural scenes is often investigated using static images (Foulsham & Underwood, 2008; Henderson, 2003), but it is not
always clear how well this research transfers to the dynamic displays that are a key feature of real world settings. Howard, Troscianko, Gilchrist, Behera and Hogg (2009) stated that measuring eye movements during CCTV monitoring might produce informative data to determine what strategies people use when attending to footage.

Two eye movement measures were selected for data analysis; fixation count (the number of fixations on a target) and fixation duration (the average length of time spent fixating on the target). Tatler, Kirtley, Macdonald, Mitchell and Savage (2014) state that fixation behaviour in scene perception gives an insight into how we cope with the ongoing changing information requirements for the behaviours/tasks we are involved in (e.g. observing CCTV footage). For example, Land, Mennie and Rusted (1999) investigated fixation behaviour during the well-learned task of making tea, in order to identify the types of monitoring actions that eyes would perform during the task. Although this task appears almost automatic, the fixation behaviour informed that eyes closely monitored every step of the tea-making process (e.g. fixating on the location of the kettle). Hayhoe, Shrivastava, Mruczek & Pelz (2003) found supporting results during a sandwich making task. Also, Findlay and Gilchrist (2001) state that when visually attending to scenes, we tend to acquire information quickly, known as the ‘gist’ information. Therefore, fixation count and fixation duration allow for measures of quick extraction of information over short periods of time. In the mock CCTV footage used in the studies presented in this thesis, each cut resulted in the camera viewpoint being present for only 5 seconds before cutting back to another camera stream, giving participants very little time to take in visual information. Where observers attend to in fast-moving scenes is crucial in terms of developing our understanding of attentional processes. Fixation behaviour not only records exactly how often and for how long observers attend to specific features in the footage, they demonstrate that significant changes in our visual field can go undetected.
By implementing a change detection paradigm in four experiments, this thesis contributes to our understanding of real-time visual strategies leading up to and during critical changes in CCTV footage. This may help to inform training courses aimed at instructing people how to optimally attend to CCTV footage. Furthermore, identifying specific visual strategies adopted by change detectors may help influence decisions on how we should attend to dynamic, constantly changing stimuli encountered in everyday life.

1.2 Thesis Outline

The central aim of this PhD thesis was to explore how observers attend to and interpret information on CCTV footage and to highlight attentional and perceptual limitations that may impact upon performance. This PhD thesis comprises four experiments described across four chapters. Using an applied change blindness task, the four experiments explored: (a) whether instructions and/or event type influence where people attend to during CCTV observation; (b) how task instructions and central and marginal information influence fixation behaviour during CCTV observation; (c) the effect of change detection on memory recall during CCTV observation; and (d) whether verbalisation, attentional set and/or repeated viewing improve change detection rates and memory recall for CCTV footage.

Chapter 2: Experiment one: CCTV observation: The effects of event type and instruction on fixation behaviour in an applied change blindness task

The experiment presented in this chapter is the first of two eye tracking studies in the thesis examining whether instructions given prior to observing CCTV footage (“detect a crime”, “detect anything unusual” or simply “watch”) or event type (criminal or non-criminal) influenced participants’ fixation behaviour. Furthermore, a change detection paradigm was included, involving a switch in location of two actors,
to test attentional and perceptual limitations during CCTV observation. The main findings were that (a) there was no effect of instructions on fixation behaviour, (b) participants who observed a criminal, as opposed to a non-criminal, event produced longer fixations on the target as the crime took place, (c) consistent with previous change blindness studies (e.g. Levin & Simons, 1997), only 24% of our participants detected the change in identity of a target male, and (d) change detectors made fewer fixations that were longer in duration on the change target (just before the change took place) compared to non-detectors. Fixation behaviour directly before the change took place was therefore a predictor of change detection. That said, fixation behaviour during the change did not differ significantly for our detectors compared to our non-detectors. A revised manuscript for this experiment is about to be re-submitted to the journal Applied Cognitive Psychology.

Chapter 3: Experiment two: CCTV observation: The role of instructions and change location on fixation behaviour in an applied change blindness task

This second eye tracking experiment in this thesis built on the findings of Experiment 1 by providing more specific instructions to participants (“focus on people” or “focus on objects”) in an attempt to increase change detection. It was hoped that instructing participants to focus on the people might improve change detection rates. We also included central and marginal changes in the footage to investigate whether participants fixated more on central information compared to marginal information. Finally, we wanted to further explore the finding from Experiment 1 that the fixation behaviour of change detectors might act as a predictor of change detection. The main findings were (a) instructions did not influence fixation behaviour, replicating the findings from Experiment 1, (b) participants fixated more and for longer on central information in the footage compared to marginal
information, (c) change location influenced change detection, with more participants detecting a central change compared to a marginal change, (d) only 34.2% of our participants detected the change, albeit slightly more than the number of change detectors in Experiment 1 and (e) fixation behaviour was a predictor of change detection, with change detectors producing more and longer fixations on the targets directly before and during the change compared to non-detectors. Therefore, not only did we replicate the finding from Experiment 1, with change detectors fixating on the target directly before the change, but change detectors in Experiment 2 also produced significantly more and longer fixations on the change target during the change compared to non-detectors.

Chapter 4: Experiments 3a and 3b: Investigating memory recall of CCTV footage using an applied change detection task

Experiments 1 and 2 demonstrated that there were significant differences in fixation behaviour between our change detectors and non-detectors during the observation of CCTV footage. Therefore, in Experiments 3a and b, we investigated whether there were other differences between the two groups that may inform us further about the cognitive strategies change detectors adopt during CCTV observation. We applied a change detection paradigm in order to investigate, in two experiments, how accurately observers could recall information from CCTV footage. We found that overall, change detectors recalled more accurate detail from the CCTV footage compared to the non-detectors, but only once the severity of the crime had increased. As with Experiments 1 and 2, there was no effect of instructions on accuracy, suggesting that top-down information may not have been as important in determining how much attention participants paid to the videos. In terms of real-world CCTV observation and eyewitness accuracy recall, we have highlighted potential
limitations in terms of observers missing large perceptual changes in their visual environment and failing to recall important information. Both Experiments 3a and 3b have been submitted for publication together in one manuscript to the journal, *Legal and Criminological Psychology*.

**Chapter 5: Experiment 4: “Play it again Sam”: The effect of repeated viewing and the ‘think aloud’ protocol on change detection rates for a mock crime scenario on CCTV footage**

In Experiments 1 and 2, we identified differences in fixation behaviour between change detectors and non-detectors, with change detectors fixating more and for longer on key targets. Experiments 3a and 3b demonstrated that the group of change detectors from Experiment 2 went on to recall more accurate detail from the CCTV footage compared to non-detectors. That said, the levels of change detection in Experiments 1 and 2 were relatively low. Experiment 4 aimed to improve the rate of change detection during CCTV observation. It also aimed to replicate the finding from Experiment 3, that change detectors would record more accurate detail from the footage than non-detectors. For the final experiment, half of the participants were asked to verbalise what they were observing as they watched CCTV footage of a mock crime, whilst the other half of participants simply watched the footage in silence. At some point in the CCTV footage, there was a change in the identity of one of the criminals. If participants failed to detect this change during the first viewing, they were given the opportunity to view the footage again, up to four times. The main findings were that (a) there was no effect of verbalisation on change detection or eyewitness recall accuracy, (b) after viewing the footage once, 59% of participants detected the change. This was the highest level of change detection recorded for this
programme of research and was no longer consistent with previous change blindness studies (e.g. Levin & Simons, 1997), and (c) after giving the participants the opportunity to watch the footage up to four times, 96% of our participants detected the change, with only four participants still failing to detect the change. This finding is positive in terms of post-event CCTV surveillance, where CCTV footage is searched repeatedly for evidence. However, there are still limitations for live CCTV surveillance, where observers only see the footage once.

Chapter 6: General Discussion

Finally, the concluding chapter discusses the main findings of this PhD thesis as well as presenting theoretical, practical and methodological implications and suggestions for future research.

1.3 References


Chapter 2: Experiment one: CCTV Observation: The Effects of Event Type and Instructions on Fixation Behaviour in an Applied Change Detection Task

Revised version to be submitted for publication to *Applied Cognitive Psychology* as:

2.1 Abstract

Little is known about how observers’ scanning strategies affect performance when monitoring events in CCTV footage. We examined the fixation behaviour of change detectors and non-detectors monitoring dynamic scenes. 147 participants observed a CCTV video featuring either a mock crime or no crime. Participants were instructed to look for either a crime, something unusual, or simply to watch the video. In both videos, two of the people depicted switched locations. Eye movements (the number of fixations on the targets and the average length of each fixation on targets) were recorded prior to and during the critical change period. Change detection (24% overall) was unaffected by event type or task instruction. The event on the footage guided fixation behaviour, but only when the event was of a criminal nature. There was no effect of instructions of fixation behaviour. Change detectors (cf. non-detectors) fixated for longer on the target directly before the change. However, fixation count and durations during the critical change period did not predict change detection. Therefore, scanning behaviour demonstrating fewer, longer fixations before change can predict change detection. These results highlight the potential value of studying fixation behaviour for understanding change blindness during complex, cognitively demanding tasks (e.g., CCTV surveillance).

2.2 Introduction

Although CCTV footage is used in both crime prevention and police investigations to prosecute criminals, relatively little is known about the strategies that observers use when monitoring and interpreting (criminal) events observed in such footage. Howard, Troscianko, Gilchrist, Behera and Hogg (2009) stated that measuring eye movements during CCTV monitoring might produce innovative data to determine what strategies people use when attending to footage. Stainer, Scott-Brown and Tatler (2013) examined the eye movements of two trained CCTV operators
monitoring multiple display screens on a wall, compared to a single spot monitor (the operator could select only one of multiple screens to inspect in more detail). They found that more attention was allocated to the single screen spot monitor than the multiplex display, with the most experienced operator looking at the spot monitor more so than the less experienced operator. Stainer, Scott-Brown and Tatler (2013) identified that their observers selectively allocated attention based on expected informativeness. This replicated the work of Howard, Troscianko and Gilchrist (2010) who showed that participants with more experience of watching football matches shifted their eyes to areas of the footage that were more informative earlier than non-experienced observers. Following on from this work, we investigated if event type and instructions affected fixation behaviour during CCTV observation. Further, we investigated whether fixation behaviour predicted change detection.

2.2.1 The Effect of Task Instructions on Fixation Behaviour

The notion that task instructions guide attention in visual scenes has been extensively researched from as early as Yarbus’s (1967) classic experiments. These studies demonstrated that eye movements are influenced by task and goals, emphasising that where individuals fixate on a scene varies according to viewing instructions given prior to the task (Mills, Hollingworth, Van der Stigchel, Hoffman & Dodd, 2011). Recent supporting evidence is demonstrated in real-world eye movement studies, with participants fixating more on task-relevant objects than the most visually salient objects (Land & Hayhoe, 2001; Tatler & Tatler, 2013). Furthermore, instructing participants to search for an object or to memorise a scene has been shown to influence fixation locations (Castelhano, Mack, & Henderson, 2009; Henderson, Weeks, & Hollingworth, 1999). In terms of dynamic real-world visual search, Howard, Gilchrist, Troscianko, Behera and Hogg, (2011) found that
task-relevance determined where observers attended whilst watching CCTV footage, with participants fixating more often on suspicious behaviour after being instructed to do so. Thus, it is clear from the literature that task instructions have a significant influence on eye movements in scene viewing. However, Castelhano et al., (2009) stressed that it is difficult to establish a clear theory or model of fixation durations in scene perception (compared to reading, e.g., Reichle, Rayner & Pollatsek, 2003) as the task and stimuli are often varied. Furthermore, the majority of current models of this behaviour are based on studies of static scene or picture viewing paradigms, meaning it is difficult to generalise these models to broader contexts such as interpreting dynamic stimuli (Tatler, Hayhoe, Land, & Ballard, 2011).

With these limitations in mind, the present study aimed to develop our understanding of how individuals visually attend to dynamic scenes by investigating the effects of task instructions on visual attention and change blindness during CCTV observation. Previous research has found that task instructions influenced the detection of changes in dynamic scenes. For example, when viewing a video of a staged burglary, people told to remember content from the video noticed a change in the burglar’s identity more often than people not given any specific instruction (Davies & Hine, 2007). However, although instructions can improve change detection, they do not eliminate change blindness. In Levin and Simons (1997) classic change blindness study, even participants instructed to explicitly look for changes only noticed two out of the nine changes present in the video. This idea of prioritising where to look in a scene based on task-goals is known as attentional set (e.g. Most, Scholl, Clifford, & Simons, 2005). This in turn aids efficient visual search challenges that are faced day to day (Leber & Egeth, 2006). Given that task instructions influence where individuals attend to in a scene (Howard et al., 2011), we predicted that our
observers would fixate on task-relevant aspects of the footage, (i.e., those instructed to detect a crime would focus on features of the footage related to the crime). In the present study, two of the actors in both the crime and no-crime videos switched locations. The criminal event (stealing a phone) in the crime video took place directly after the switching of the two actors. This period is referred to as the ‘critical change period’ throughout the rest of the chapter. It was predicted that participants instructed to ‘detect a crime’ would show more and longer fixations before and during the critical change on the targets than those instructed to ‘detect anything unusual’ or those given no instruction.

2.2.2 The Effect of Event Type on Fixation Behaviour

Although a large number of eye-tracking studies have informed how we attend to static scenes (e.g. Castelhano et al., 2009), few studies have investigated how we interpret dynamic stimuli. Therefore, the current study aims to develop an understanding of fixation behaviour during the observation of dynamic CCTV footage. Related to eye movements, the rationale for looking at both fixation durations and counts in the present study is to investigate whether the number of fixations (i.e., relatively rapid scanning) or length of fixations (i.e., more careful scanning) facilitates change detection.

There are parallels between the visual strategies applied to events in CCTV footage and the perceptual research into how we observe and understand films. For instance, the presentation of the majority of CCTV footage and film footage is similar in that the information tends to be formed of several camera angles and cuts. Therefore, it makes sense that the researchers looking at the perceptual and cognitive understanding of films are applying findings from the eye tracking of dynamic scenes (Smith, Levin & Cutting, 2012). For instance, Mital et al., (2011) found that observers
attend to areas of high motion in a dynamic scene. Furthermore, Hirose, Kennedy and Tatler (2010) investigated participant’s recognition memory and eye movement patterns whilst observing short video clips involving a viewpoint change (a cut). During the cut, an objects shape, colour, identity or position was manipulated. They found that memory for object location in a scene is significantly worse than memory for object identity or colour. Therefore, combining how we perceptually understand films with our interpretation of real-world dynamic scenes may further our understanding of how we understand events in dynamic, CCTV footage.

It is not just the nature of the event the may impact eye movements, but the type of event. Previously we discussed the influence of task instructions of eye movements. However, existing research has shown that the actual task/event and level of expertise can significantly influence where we attend to. Land & Tatler (2001) investigated the eye movements of a racing driver compared to normal drivers to see how they absorb visual information. Whilst driving down a winding road, they observed that the racing driver demonstrating advanced anticipatory behaviour, such as rotating their head proportionally to the estimated car rotation speed so it is in line with the expected tangent points in curves on the road. This behaviour has been found not to be present in novice drivers (Underwood, Chapman, Brocklehurst, Underwood & Crundall, 2003), showing an effect of expertise evident from eye movement behaviour. Further expertise research (Land & McLeod, 2000) found that skilled cricket batsmen, when anticipating the bounce of the ball, produced saccadic eye movements towards the bounce point of the ball 100 ms earlier than less skilled players. In a medical context, expert radiologists have been found to detect targets in medical images more quickly (Krupinski, 1996) and more accurately than less experienced radiologists (Donovan & Litchfield, 2013). Snowden, Davies and Roling (2000) state that
novice’s detection of targets can be improved through training and perceptual learning. More recently, Litchfield and Donovan (2016) wanted to investigate if providing expert radiologists and novice observers with an initial scene preview of the medical image would improve detection of targets. They found that that expert’s performance was better than novices but not contingent on seeing the scene preview. However, novice observer’s performance was impaired by the scene preview. These findings highlight the importance of recognising potential costs of training novices with methods that lead to further impairment in performance compared to experts. There are huge implications if radiologists were to fail to detect important visual information in medical images. Just as there are huge implications if CCTV observers miss crucial visual information in footage related to serious criminal offences.

No research to date has directly compared eye movements for criminal and non-criminal events. We included both criminal and non-criminal footage for two reasons. First, real-world CCTV footage features both criminal and non-criminal events. Second, observers will rely on cues from footage to help them understand what is happening concurrent with any expectations they have about what constitutes suspicious behaviour. Therefore, criminal events may provide specific, attention grabbing cues which may influence fixation behaviour and consequently change detection.

Half of our participants viewed a crime scenario and the other half viewed similar footage but no crime took place. No specific hypotheses were made, however, we wanted to investigate how event type impacts fixations behaviour and, whether either of these events predicts change detection behaviour.

2.2.3 Change Blindness

Observing CCTV footage can place a huge demand on the visual system, yet almost all of our visual processing is seemingly effortless and automatic (Scott-Brown
This overarching feeling of visual completeness can unfortunately lead to an overestimation of our visual abilities, and psychological research has powerfully demonstrated that our perceptual systems can fail to detect changes in the environment (Scott-Brown & Cronin, 2007). An example of this is inattentional blindness (IA), which refers to observers failing to detect an unexpected object in their visual field, usually whilst attention is directed towards another task or object (Mack & Rock, 1998). The earliest research example of IA comes from Neisser and Becklen (1975) who created a selective looking task in which participants had to watch one of two superimposed videos (one video showed a hand-slapping game and the second video featured three people bouncing or passing a basketball). Participants were asked to attend to one of the films and asked to press a key when a target event occurred (a hand slap or the passing of the basketball). Neisser and Becklen (1975) found that participants failed to notice unexpected events in the unattended film (e.g. one of the pairs of hands from the hand-slapping game suddenly passing a ball).

A similar visual phenomenon to IA is called change blindness and refers to an inability to detect changes in our perceptual environment from one view to the next (Levin & Simons, 1997). Early experiments investigating change blindness (e.g. Blackmore, Brelstaff, Nelson & Troscianko, 1995; Grimes & McConkie, 1995) demonstrated that observers fail to detect large changes to pictures of objects or real-world photographs, concluding that an eye movement or flashed blank screen (see Rensink, O’Regan, and Clark (1997) for an example of the Flicker-paradigm) may increase difficulty in detecting changes to the visual details of a scene. This is due to the stable nature in which we believe we are interpreting our visual environment and an overestimation of how much of it we are attending to (Simons & Levin, 1998). Hollingworth and Henderson (2000) subsequently found that observer’s detection
accuracy was higher when objects were inconsistent as oppose to consistent with a visual scene.

Further classic change blindness studies have demonstrated that observers can miss the change in identity of an actor between a cut in camera angle (Levin & Simons, 1997). Astonishingly, observers also miss changes during real-world interactions (see Simons & Levin, 1998). It can also have important applied implications for security settings. For example, it is important to investigate change blindness in CCTV monitoring as failures to detect change in applied forensic contexts (e.g., a switch between two people as a crime takes place leading to wrongful arrest) can have serious consequences.

There has been little research investigating the visual strategies of change detectors and non-detectors. Considering the aim of change blindness studies is to test perceptual limitations when attending to scenes (Simons & Rensink, 2005), it would be beneficial to develop an understanding of real-time fixation behaviours leading up to and during change blindness. This may help to inform training courses aimed at instructing people in optimal techniques for attending to CCTV footage. Furthermore, identifying specific visual strategies adopted by change detectors may help influence decisions on how we should attend to dynamic, constantly changing stimuli.

Previous CCTV studies have demonstrated that observers use specific cues from CCTV footage (i.e., body position and gesture) to determine if criminal behaviour is about to take place (Troscianko et al., 2004). This crucial information is attended to directly before the criminal event takes place in the footage. Other research has used eye movements as a predictive behaviour. For example, in a sporting context, Savelsberg, Van der Kamp, Williams and Ward (2007) found that expert football players demonstrated accuracy at predicting the height and direction of
penalty kicks. Furthermore, they produced longer fixation durations on the opponent’s non-kicking leg prior to the penalty kick. The eye movements before the action provided an insight into the strategies adopted by this expert group. A real-world eye tracking study by Pelz and Canosa (2001) found that participants completing a hand washing task sometimes produced look-ahead fixations, which were related to future actions associated with the task (e.g., looking at a kettle before picking it up to pour water into a cup). Therefore, we investigated whether we could apply the notion of look-ahead fixations (Pelz & Canosa, 2001) to a dynamic, observational task where anticipatory eye movements may fall on people associated with the task goal (e.g., fixating for longer on suspicious people before the crime is committed). Successful change detection may occur in the present study if participants fixate on the target directly before the change takes place. Furthermore, instructions might guide attention to certain aspects of the scene, increasing the chances that participants are looking at the target prior to the change, and consequently increasing the likelihood of change detection.

We wanted to explore whether there are differences in fixation behaviour between those who detected a change in the CCTV footage and those who exhibited change blindness. If there are differences in fixation behaviour between the two groups (i.e. change detectors fixate for longer on the target), this may be a useful predictor of change detection.

In summary, this study aimed to investigate if event type and instructions affect fixation behaviour. From this, does fixation behaviour go on to predict change detection?
2.3 Method

2.3.1 Pilot Study

A pilot study was run to establish that participants were able to identify that one video depicted a crime and that there was no crime taking place in the other video. It was also critical that a portion of the observers were able to identify the change taking place in the videos in order to avoid ceiling effects on change detection.

2.3.1.1 Participants

40 undergraduate students participated in the experiment (29 females, 11 males). Participant ages ranged from 18 years to 46 years ($M = 24.50$ years, $SD = 7.45$ years).

2.3.1.2 Materials: CCTV footage

Mock CCTV footage was filmed using two JVC Everio digital cameras (model number GZMG750BEK), and the footage was edited using Adobe Premier Pro. The two black and white CCTV videos created after editing were identical except for a 5 second segment. In that segment, one video showed a crime taking place and the other showed the continuation of non-criminal behaviour. Participants were told that the videos showed six people entering, sitting and leaving the room of a doctors’ surgery. Each video was two minutes in length and alternated every five seconds between two different camera viewpoints showing different parts of the doctor’s waiting room (see Figure 2.1). The reason for the alternating camera viewpoints is twofold. First, it allowed for change blindness to take place between a cut in camera angle, which has been used successfully as a method in previous change blindness research (see Levin & Simons, 1997). Second, it approximates real-life CCTV footage that switches between different streams.
In the crime video, a male stole a phone that was left on one of the chairs by a female. In the non-crime video, the female returned to collect the phone from the chair (see Figure 2.2).
After the 1:25 mark, following a switch in the camera perspective, the two target actors change position (see Figure 2.2). This change occurred immediately prior to the phone event taking place. That is, in the first scene showing Target 1 in his new position, the phone event took place (see also Figures 2.3 and 2.4). Target 1 then goes on to steal the phone. Therefore, Target 1 is the thief in the crime video.

Figure 2.2: An illustration of the key sequence in the two minute video showing the two different camera viewpoints, the change and the crime and no-crime experimental conditions (adapted from Hirose, Kennedy & Tatler, 2010). The criminal event shows the male picking up the phone that has been left by the lady exiting the seated area. The male proceeds to place the phone in his pocket. In the non-criminal event, the lady returns to collect her phone after realising she has dropped it. No crime is committed. The purple dots represent an example of the position of an observer’s eye movement.
2.3.1.3 Procedure

Observers watched one of two mock CCTV videos: involving a criminal or non-criminal event. Both the crime and non-crime videos were uploaded to an online survey site (PsychSurvey.org), allowing participants to complete the study off-campus. After viewing the footage, observers were asked the following questions about the videos: 1. Is there a criminal event taking place in the video (if yes, please describe it)? 2. Did you notice any changes in the video (if yes, describe it)? 3. Any general comments?

2.3.1.4 Results

The videos were regarded suitable for the main experiment because 100% of the observers in the crime event condition identified that a crime took place and no participants in the no-crime conditions said a crime took place. Moreover, 40% of the pilot participants spotted the change in location of a person in either the crime or no-crime video.

2.3.2 Main Study

2.3.2.1 Participants

147 participants took part in the experiment (91 females, 56 males). The participants consisted of undergraduate students and staff at the University of Portsmouth. Psychology students and staff were not permitted to complete the study due to potential prior knowledge of change blindness and expectations of the nature of the study. Participants ages ranged from 18 years to 50 years ($M = 29.62$ years, $SD = 6.91$ years). All participants reported having normal or corrected-to-normal vision.

2.3.2.2 Design

Event type (crime or no crime) and Instruction (“detect crime”, “detect anything unusual”, or no instruction) were manipulated between-subjects. The dependent measures were two measures of eye movements: fixation count (the
number of fixations on the targets) and fixation duration (average time of each fixation on targets measured in milliseconds).

Change detection was recorded, for each condition, as the percentage of the participants who correctly detected the change. In subsequent analyses change detection was used as an outcome variable to ascertain whether or not change detection influenced eye movements. For the remainder of the chapter the two actors who switched location in the videos will be referred to as the “Target 1” and “Target 2” (see Figure 2.3).

![Figure 2.3](image)

Figure 2.3: The two targets who switched location in the crime and no crime videos.

### 2.3.2.3 Materials

The videos (as described for the Pilot Study) were presented on a computer monitor. Experiment Builder software (SR Research, Ltd, Osgoode Canada) was used to programme the experiment. A second computer, used to control the eye tracker, was linked to the computer presenting the videos. The video-based EyeLink 1000 (SR Research, Ltd, Osgoode Canada) was used to record participants’ eye movements, and was run at 1000 Hz while tracking both pupil and corneal reflection. A chin-rest was used to maintain the participants’ viewing position of 50 cm from the computer monitor.
2.3.2.4 Procedure

After obtaining informed consent from participants, the measurements of the eye-tracker were calibrated using a nine point grid. Calibration was repeated, if necessary, until predicted and actual fixation position differed by no more than 0.5°.

Participants were randomly allocated to watch one of the six experimental conditions. The relevant instruction appeared on the screen before the video played. Participants were given as much time as they needed to read the instruction before clarifying to the experimenter that they understood and were happy to proceed. Participants then watched a video clip. Eye tracking was stopped once the video finished.

After the experiment, participants completed a questionnaire measuring recall from the footage and establishing whether or not they detected the change. If participants stated that they detected a change, they were asked to describe the change, and rate their confidence that they saw a change (see Appendix 2.1). Participants were told that they had as much time as required for answering the questions. Participants were then fully debriefed. The experiment lasted approximately 20 minutes.

2.3.2.5 Data Screening

Fixation durations were only included if they were 100 ms or longer. Raw eye movement data was analysed using Dataviewer (SR Research, Ltd, Osgoode Canada) software. The two minute videos were edited down to two key stages for analysis; the five seconds immediately before the critical change period and the 10 second critical change period in which the two males each appeared for the first time in their respective switched positions (see Figure 2.4). Fixation count and fixation duration served as the dependent variables, with these parameters representing the number of times the targets were fixated on and for how long.
1. Before change (5 seconds)  
2. Change period, target 1 (5 secs)  
3. Change period, target 2 (5 secs)

Figure 2.4: Stills taken from the CCTV footage depicting the two key stages where eye movement behaviour of our observers was examined. Still (1) portrays the 5 seconds immediately before the change occurs. Stills (2) and (3) represent the critical change period. Still (2) is the first 5 seconds of the change period featuring target 1 and still (3) is the last 5 second of the change period featuring target 2.

2.4 Results

2.4.1 Change Detection

Of the 147 participants tested, only 36 detected the change (24.5%, see Table 2.1). Chi-square tests were performed to see if event type or instruction were associated with change detection. There was no relationship between event type and change detection, $X^2 (2, N = 147) = .185, p = .705$. That is, witnessing a criminal or non-criminal event did not impact change detection. There was also no relationship between Instructions on change detection, $X^2 (2, N = 147) = .519, p = .787$. Therefore, it made no difference whether participants were asked to detect crime, detect anything unusual or simply watch the video on change detection.
Table 2.1: Change detection as a function of event and instruction type.

<table>
<thead>
<tr>
<th>Change detected</th>
<th>Event type</th>
<th>Instruction Type</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-detectors</td>
<td>Crime</td>
<td>Detect crime</td>
<td>20</td>
<td>19</td>
<td>18</td>
<td>57</td>
</tr>
<tr>
<td></td>
<td>No-crime</td>
<td></td>
<td>16</td>
<td>18</td>
<td>20</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td></td>
<td>36</td>
<td>37</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>Detectors</td>
<td>Crime</td>
<td>Detect unusual</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>No-crime</td>
<td></td>
<td>8</td>
<td>7</td>
<td>4</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Overall</td>
<td></td>
<td>13</td>
<td>13</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

2.4.2 Eye Movement results

2.4.2.1 Before Change

A MANOVA was conducted with Event type (crime or no crime), and Instruction (“Detect Crime”, “Detect Anything Unusual”, or simply watch the video) as the independent variables and number of fixations on targets (fixation count) and average fixation duration in the 5 seconds before the critical change as the dependent variables. This analysis addressed our first research question: do event type and task instructions affect fixation behaviour?

The MANOVA revealed a significant multivariate main effect for Event type, Wilks’ $\lambda = .949$, $F (2, 140) = 3.74, p = .026$, partial $\eta^2 = .051$. As the content of both
the crime and no-crime videos were exactly the same before the crime took place, we expected there to be little difference in fixation count and duration between the observers watching the criminal event compared to the non-criminal event. However, a follow-up univariate analyses revealed a significant main effect of Event type on fixation count, $F(1, 147) = 5.48, p = .021$, partial $\eta^2 = .087$, with fewer fixations being made when participants were viewing the crime video ($M = 4.78, SD = 2.15$, 95% CI [4.31, 5.30]) compared to the no-crime video ($M = 5.68, SD = 2.46$, 95% CI [5.12, 6.27]). However, there was near significance related to longer fixation durations, $F(1, 147) = 3.77, p = .054$, partial $\eta^2 = .026$, made by the participants watching the crime video, ($M = 450.51 ms, SD = 467.41$, 95% CI [353.77, 571.42]) compared to those watching the no-crime video, ($M = 337.46 ms, SD = 170.16$, 95% CI [301.32, 376.53]). Thus, participants watching the no-crime video produced more fixations on the target, and there is a hint that participants watching the crime video produced longer fixations on the Target.

The MANOVA revealed no significant multivariate main effect of Instruction, Wilks’ $\lambda = .991, F(1, 147) = .30, p = .875$, partial $\eta^2 = .004$. In addition, no significant univariate main effects for Instruction were obtained for fixation count, $F(1, 147) = .49, p = .608$, partial $\eta^2 = .007$, or fixation duration, $F(1, 147) = .22, p = .803$, partial $\eta^2 = .003$. Therefore, instructions did not affect scanning behaviour.

Although no specific hypotheses were made, a simple linear regression was calculated to ascertain whether fixation count immediately before the change took place was a predictor of change detection. A significant regression equation was found, $F(1, 145) = 6.564, p = .011$, $R^2 = .043$. Participant’s predicted Change detection was equal to $0.397 + - .029$ fixations (number of fixations). A simple linear regression was also calculated to ascertain whether fixation duration immediately
before the change took place was a predictor of change detection. A near significant regression equation found, $F (1, 145) = 3.702, p = .056, R^2 = .025$. Participant’s predicted Change detection was equal to $.145 + .000$ fixation duration (in msecs). Therefore, these results are consistent with a pattern indicating that fewer fixations that are longer in duration just before the change period predicted change detection.

### 2.4.2.2 Critical Change Period

The switch in location of the two targets took place over two scenes, therefore the critical change period analyses were split by Target (Target 1 from scene 1 and Target 2 from scene 2, see Figure 2.5). For each target, we ran a MANOVA to test whether event type and instruction affected fixation behaviour and used regression analyses to test whether fixation behaviour predicted change detection.

![Figure 2.5: Still (a) represents ‘target 1’. At this point in the video, target 1 has switched from his original position. This is the very first point in which our observers may identify that the change has taken place. Target 1 remains on screen for 5 seconds during the critical change period. Still (b) represents ‘target 2’. This is the first time observers see target 2 in his new position after switching with target 1. Target 2 remains on the screen for 5 seconds. The critical change period lasts 10 seconds, which gave our participants time to see both of our targets after they had switched positions. The analysis considers target 1 and target 2 separately.](image)
2.4.2.3 Target One

A MANOVA was conducted with Event type (crime or no crime) and Instruction (“Detect Crime”, “Detect Anything Unusual”, or simply watch the video) as the independent variables. There were two dependent variables, (i) number of fixations (fixation count) on target 1 and (ii) average fixation duration on target 1.

The MANOVA revealed a significant multivariate main effect for Event type, Wilks’ $\lambda = .646$, $F(1, 147) = 38.40$, $p < .001$, $\eta^2 = .354$. It was predicted that attention would be allocated to criminal behaviour compared to non-criminal behaviour; therefore observers watching the crime video would produce more and longer fixations on Target 1 during the change than those watching the no-crime video. A significant univariate main effect was obtained for Event type on fixation count, $F(1, 147) = 77.28$, $p < .001$, $\text{partial } \eta^2 = .354$, with more fixations on Target 1 made when participants were viewing the crime video ($M = 5.96$, $SD = 2.32$, 95% CI [5.43, 6.48]) compared to the no-crime video ($M = 2.93$, $SD = 1.94$, 95% CI [2.42, 3.34]). There was no significant main effect of Event type on fixation duration, $F(1, 147) = .04$, $p = .842$, $\text{partial } \eta^2 = .000$. Participants watching the crime video produced more fixations overall compared to those watching the no-crime video. However, these fixations were shorter in duration.

The MANOVA revealed no significant multivariate main effect of Instruction, Wilks’ $\lambda = .958$, $F(2, 140) = 1.52$, $p = .196$, $\text{partial } \eta^2 = .021$. In addition, providing instruction prior to CCTV observation did not significantly impact the number of fixations, $F(2, 147) = 2.67$, $p = .073$, $\text{partial } \eta^2 = .036$, or fixation duration, $F(1, 147) = .44$, $p = .646$, $\text{partial } \eta^2 = .006$. Therefore, no support was found the prediction that participants instructed to ‘detect a crime’ would show more and longer fixations on the Target during the critical change than those instructed to ‘detect
anything unusual’ or those given no instruction. The MANOVA revealed no significant interaction effects of Event type and Instructions, Wilks’ $\lambda = .959$, $F (4, 140) = 1.49$, $p = .205$, partial $\eta^2 = .021$. 

Although no specific hypotheses were made, a simple linear regression was calculated to ascertain whether fixation count immediately before the change took place was a predictor of change detection. A non-significant regression equation was found, $F (1, 145) = .219$, $p = .640$, with an $R^2$ of .002. A simple linear regression was also calculated to ascertain whether fixation duration immediately before the change took place was a predictor of change detection. A non-significant regression equation found, $F (1, 145) = 1.770$, $p = .185$, with an $R^2$ of .012. Therefore, the number and duration of fixations on Target 1 were not useful predictors of whether or not changes were detected during the critical change period.

2.4.2.4 Target Two

A MANOVA was conducted with Event type (crime or no crime) and Instruction (“Detect Crime”, “Detect Anything Unusual”, or simply watch the video) as the independent variables. There were two dependent variables, (i) number of fixations (fixation count) on Target 2 and (ii) average fixation duration on Target 2.

The MANOVA revealed a significant multivariate main effect for Event type, Wilks’ $\lambda = .733$, $F (2, 140) = 25.48$, $p < .001$, $\eta^2 = .267$. A significant univariate main effect was obtained for Event type on fixation count, $F (1, 147) = 29.66$, $p < .001$, $\eta^2 = .174$, with more fixations made when participants were viewing the crime video ($M = 7.18$, $SD = 2.66$, 95% CI [6.58, 7.75]) compared to the no-crime video ($M = 5.07$, $SD = 2.11$, 95% CI [4.56, 5.54]). There was no significant main effect of Event type on fixation duration, $F (1, 147) = 3.16$, $p = .078$, $\eta^2 = .022$. As with Target 1,
participants watching the crime video produced more fixations overall compared to those watching the no-crime video.

The MANOVA revealed no significant multivariate main effect of Instruction, Wilks’ $\lambda = .959, F(4, 280) = 1.48, p = .209$, partial $\eta^2 = .021$. In addition, no significant univariate main effects for Instruction were obtained for fixation count, $F(2, 147) = 2.30, p = .104$, partial $\eta^2 = .032$, or fixation duration, $F(2, 147) = .05, p = .948$, partial $\eta^2 = .001$. Therefore, instructions did not affect fixation behaviour. The MANOVA revealed no significant interaction effects of Event type and Instructions, Wilks’ $\lambda = .967, F(4, 140) = 1.91, p = .315$, partial $\eta^2 = .017$.

Although no specific hypotheses were made, a simple linear regression was calculated to ascertain whether fixation count immediately before the change took place was a predictor of change detection. A non-significant regression equation was found, $F(1, 145) = .015, p = .904$, with an $R^2 = .001$. A simple linear regression was also calculated to ascertain whether fixation duration immediately before the change took place was a predictor of change detection. A non-significant regression equation found, $F(1, 145) = .054, p = .816$, with an $R^2 = .001$. Therefore, the number and duration of fixations on Target 2 were not useful predictors of whether or not changes were detected during the critical change period.

2.5 Discussion

We examined the fixation behaviour of participants, who were given varying instructions, watching CCTV footage that depicted a crime or no-crime. A change detection paradigm was included, involving the switching of location of two targets during a cut in camera angle. Specifically, we were interested in three main issues. First, we examined whether the nature of the event being viewed (criminal versus non-criminal) would influence where people attended. Second, we examined how task
instructions influenced how people attended to a dynamic scene with a large array of factors competing for attention. Third, we examined whether differences in fixation behaviour could differentiate between those who detected a change (change detectors) and those who experienced change blindness (non-change detectors). One striking finding was that all of our significant results related to the CCTV footage depicting a criminal event. No differences in eye movement behaviour were found for participants watching the non-crime video.

2.5.1 The Role of Task Instructions on Eye Movements

Instructing participants to detect a crime, detect anything unusual, or simply watch the footage produced no significant effect on eye movement behaviour immediately before the change took place, or during the critical change period. This result was initially surprising, as previous research found that task instructions influence observers’ visual attention (Howard et al., 2011). Thus, we expected our observers would fixate on task-relevant aspects of the footage (i.e., those instructed to detect a crime would focus on features of the footage potentially related to a crime).

Previous research using static, picture based paradigms found that instructing participants to search for an object or to memorise a scene influenced the locations they fixated on (Castelhano et al., 2009; Henderson et al., 1999). However the findings from this study highlight the complexity of how we attend to dynamic scenes based on task instructions, with findings showing that eye movement behaviour can change dramatically from one five second camera view to the next. Unlike static images, were the context is stable during observation, dynamic scene viewing involves the constant updating and changing of the visual information available. This supports the conclusion of Howard et al. (2009, p. 5) who stated that “the visual complexity of CCTV images, and their dynamic nature are likely to influence
performance in a manner that is very different from the static, simple stimuli used in the laboratory”.

2.5.2 The Role of Event Type on Eye Movements

In terms of the effect of Event type (crime versus no-crime) on eye movements, one finding stood out regarding the different fixation patterns immediately before the change took place and during the critical change period. Immediately before the change took place, participants watching the crime video made fewer fixations on target, however their fixations were significantly longer in duration compared to those watching the no-crime video. In contrast, during the first part of the critical change period, there were more fixations on Target 1 from participants watching the crime video compared to those watching the no-crime video, however there was no effect of event type on fixation durations. One explanation for this is that the switching of targets took place at exactly the same time as the crime. The large number of fixations on the target during the crime could be the result of an increase in the complexity of the footage and the need to try to understand the unfolding criminal event. Therefore, more fixations were necessary to process the visual information (Birmingham, Bishof & Kingstone, 2008).

To further examine the role of fixation behaviour during CCTV observation, similar tests with expert CCTV operators should be undertaken to establish if they would perform more accurately and in a similar nature to our change detectors. Previous research has shown that experts in particular fields such as driving (Underwood et al., 2003; Land & Tatler, 2001) cricket (Land & McLeod, 2000) and radiography (Donovan & Litchfield, 2013, Litchfield & Donovan, 2016) show significantly different eye movements to novices. Therefore, future research will establish whether there is an expertise effect when observing events CCTV footage.
The findings from this study suggest that attention is drawn towards criminal events, as there were no significant fixation behaviours during the observation of non-criminal events. This is important in terms of real-world CCTV observation as it suggests that observers will be drawn to criminal acts. Participants may have fixated on the Target (the offender) in this study in anticipation of something taking place and then continued focusing as the crime was committed. However, our findings have shown that even with participants fixating on the offender, who went onto switch locations with another person in the video, our ‘change’ was still missed by the majority of participants. It may be that the crime being the central feature in the CCTV footage influenced fixation behaviour. Future research should test attention to changes both centrally and in the periphery of CCTV footage.

2.5.3 Change Detection

In line with previous change blindness research (Levin & Simons, 1997, O’Regan et al. 2008), a large number of participants in the current study failed to detect the change in the videos. Additionally, change detection rates were unaffected by instruction and event type. As predicted, change detectors differed in their eye movement behaviour from the non-detectors. However these findings were not straight forward.

Directly before the critical change took place, change detectors watching the criminal event produced longer fixation durations on target compared to non-detectors watching the criminal event. Interestingly, there were no differences in fixation behaviour for detectors and non-detectors in the non-crime condition. There are two important points to make regarding these results. Firstly, one of our most interesting findings is the idea that eye movements before a change occurred may be a useful predictor of whether observers will detect a change. Our regression analysis produced
a significant effect of fixation duration on change detection: longer fixation durations predicted change detection. This coincides nicely with our argument above that our participants fixated ‘ahead’ on our target in an anticipatory fashion, which in turn led to successful change detection. It also supports previous research that has found that anticipatory eye movements may fall on people associated with the task goal (Pelz & Conosa., 2001; Savelsberg et al., 2007). However, as there was no effect of instructions on fixation behaviour, it may be that participants were anticipating criminal behaviour due to the task involving viewing CCTV footage, which is most commonly associated with crime, more so than the actual instructions provided prior to viewing.

Secondly, for both the criminal and non-criminal events, the CCTV footage leading up to the change was exactly the same. So why was there a difference in fixation duration behaviour between those randomly assigned to watch the criminal event compared to those watching the non-criminal event before any difference had occurred in the footage? There was no significant effect of instructions on fixation duration before the change so it may be solely down to the observers understanding of the footage unfolding in front of them.

In this study, participant’s fixation behaviour directly before the change took place was found to be a useful predictor of change detection. However, this was only the case when the event on the CCTV footage was of a criminal nature.

2.5.4 Conclusion

The present study is the first to investigate fixation behaviour of change detectors and non-detectors in dynamic scenes. There was no effect of instructions on fixation behaviour. The event on the CCTV footage guided eye movement behaviour in our study, but only when the event was of a criminal nature. Therefore, the fixation
behaviour suggests that the crime drew the observer’s attention. Fixation behaviour before a change occurred may be a useful predictor of whether observers will detect a change, with evidence of longer fixations on the target prior to the change predicting change detection. However, fixation count and durations during the critical change period did not predict change detection. Therefore, fewer, longer fixations may benefit change detection. This is consistent with participants fixating ‘ahead’ on the target in an anticipatory fashion, which in turn led to successful change detection. The findings highlight perceptual and attentional limitations faced during the observation of complex, dynamic displays.

2.6 References


Smith, T. J. (2010). Film (cinema) perception.


Chapter 3: Experiment two: CCTV Observation: The Role of Instructions and Change Location on Fixation Behaviour in an Applied Change Detection Task
3.1 Abstract

Little is known about how factors such as task instruction and central versus marginal events influence fixation behaviour during dynamic visual search. We examined the fixation behaviour of change detectors and non-detectors monitoring CCTV footage. Seventy-six participants observed a CCTV video featuring a crime. Participants were instructed to focus either on the people or the objects during observation. The videos featured changes that occurred in both central and marginal locations. Eye movements (the number of fixations on the targets and the average length of each fixation on targets) prior to and during the critical change period were recorded. Change detection (34.2% overall) was unaffected by instructions but was influenced by change location, with more people detecting the central change compared to the marginal change. There was no effect of instructions on the number and duration of fixations. However, participants made more and longer fixations on the central change in the footage compared to the marginal change. Fixation behaviour was also a predictor of change detection, with change detectors producing more and longer fixations on the targets directly before and during the change. These results demonstrate significant fixation behaviour differences between change detectors and non-detectors. They also highlight potential attentional and perceptual limitations during CCTV observation.

3.2 Introduction

Closed-circuit television (CCTV) cameras have become a prominent feature in Britain, with Norris and Armstrong (1999) estimating that, in the average urban environment, a person may be captured on over 300 cameras on thirty separate CCTV systems. This, along with the ever-increasing potential threats arising from international/domestic terrorism (Scott-Brown & Cronin, 2008), has led to increasingly more criminal investigations using visual images as primary evidence.
(Davis, Lander, Evans & Neville, 2012). CCTV research has established that trained observers can predict the onset of antisocial behaviour from footage (Troscianko, Holmes, Stillman, Mirmehd, Wright & Wilson, 2004). Stainer, Tatler and Scott-Brown (2013) found that CCTV operators spend more time attending to the single-scene spot monitor in the control room compared to viewing the multiplex wall and Howard, Gilchrist, Troscianko, Behera and Hogg (2011) observed participants prioritising fixating on suspicious aspects of several CCTV displays. Monitoring CCTV footage is also a cognitively challenging task. For example, when British teenager Alice Gross went missing in Ealing, London in August 2014, police had to review material from approximately 300 CCTV cameras (Agencies, 2014). Despite this, very little is still known about human performance and task goals during CCTV monitoring.

3.2.1 Task Instructions

When considering how observers visually attend to scenes, the earliest research found that there were centres of interest in complex scenes that were constantly looked at by the majority of observers (Buswell, 1935). However, after presenting the same image but with different instructions, Buswell found that observer’s fixation behaviour changed depending on the instruction provided. Yarbus (1967) supported Buswell’s conclusion with his classic eye movement studies demonstrating that instructions given to observers change how they inspect a scene (see Tatler, Wade, Kwan, Findlay & Velichkousky, 2010 for an overview of Yarbus’s work). More recently, research (e.g. DeAngelus & Pelz, 2009) has demonstrated that having a clear task goal aids the interpretation and understanding of fixation behaviour. For example, when we engage in a natural task essentially all the fixations fall on task relevant objects (see Land, Mennie & Rusted, 1999). Despite a large body
of work on task instructions and eye movements in static scenes (e.g. Castelhano, Mack, & Henderson, 2009) very little is known about the role of task goals on eye movements during real-world dynamic visual search (Howard et al., 2011).

CCTV surveillance is dynamic in nature due to the constantly changing information presented in the footage and a large number of factors competing for observers’ attention (Howard, Troscianko, Gilchrist, Behera & Hogg, 2009). In this context, instructions provided before surveillance have been shown to influence where observers attend to in the footage. Howard et al., (2011) instructed their participants to look for suspicious events in CCTV footage and found that the participants went on to fixate on areas of the scene depicting suspicious behaviour. In Chapter 2, we instructed participants to “detect crimes”, “detect anything unusual” or simply “watch” CCTV footage that depicted criminal or non-criminal events. Despite participants fixating significantly more on the criminal in the crime video, there was no effect of instructions on fixation behaviour. We concluded that it may be the nature of the unfolding event, in this case the crime, guiding fixation behaviour more so than the instructions.

In this experiment we decided to only show a criminal event on CCTV footage and provided more specific instructions to our participants. Participants were instructed to focus on the people in the footage or they were instructed to focus on the objects in the footage. We predicted that the instructions would guide fixation behaviour, with more and longer fixations directed to either people or objects dependent on instruction condition.

3.2.2 Central and Marginal Events

Some events are more likely to capture attention than others, with observers identifying important information from purely visual cues (Troscianko et al., 2004).
One important related question is how observers attend to information deemed as central to an event compared to information deemed marginal or incidental. For example, when viewing CCTV footage, an observer might witness a fight breaking out in the middle of a busy road. At the same time and in the same context, another man may run out of a shop carrying several bottles of alcohol under his jacket. It is likely that the majority of observers would attend to the fight in the street as multiple people are involved and the fight is emotive in nature. The shoplifting crime can be classified as a marginal event, as there is no interaction between the criminal and anyone else and it does not evoke reactions from other people. Baldwin and Baird (2001) argued that when observing people in motion, we are interested more in their underlying intentions (i.e. will they go on to commit a crime) as opposed to their surface behaviours. Therefore, judgements about the intentions of others dictate how we respond, understand and attend to people in scenes (Baldwin & Baird, 2001). We can relate this back to the example and predict that observers would respond and attend to the fight in the busy road involving multiple people as the intentions of those involved are clear. The intentions of the shoplifter are less clear from the visual information that is provided at the time.

In the past, researchers have been interested in how we attend to scenes and what aspects of a scene capture attention. For example, Christianson, Loftus, Hoffman and Loftus (1991) found that participants observing emotional slides depicting a cycling accident recalled more accurate central detail compared to peripheral detail. However, it is important to note that, when viewing static stimuli like still pictures, patterns of eye movement are rather more constrained than when viewing dynamic stimuli (Land, 2006).
When we consider real-world dynamic tasks, our visual system provides crucial information at the right time and from the right place, and the patterns of fixations are unique to the particular task (Land, 2006). For example, when driving, a driver must simultaneously keep the car in lane, avoid other traffic and be aware of road signs. Underwood, Chapman, Berger and Crundall (2003) recorded the eye movements of both novice and experienced drivers whilst observing video recordings taken from a moving car. Both experienced and novice drivers fixated on objects of central interest compared to objects of marginal/incidental interest. Experienced drivers recalled more of the incidental events (i.e. recalling the colour of a car parked by the side of the road) than novice drivers. However, both groups were similar in terms of their recall of central events (i.e. recalling the colour of a car that had just overtaken them). These results along with previous research (e.g. Christianson et al., 1991) suggest that we should expect increased attention on central objects during potentially hazardous situations, resulting in reduced recall of incidental object information.

In a CCTV context, there are implications if observers only attend to central information. No study to date has investigated the role of central and marginal events on fixation behaviour during CCTV observation. This experiment aimed to investigate whether the findings from previous research investigating the recall of central versus marginal details, could be replicated during the observation of an emotive crime scenario depicted via CCTV footage. That is, we aimed to investigate whether our observers would fixate on central information in the footage (the exact location of a crime) compared to marginal information (a woman sitting talking on her phone). We predicted that observers would fixate more and for longer on targets related to a central event compared to targets related to a marginal event. What is less clear from
the literature is whether these findings are applicable to CCTV observation and whether important information is missed during cuts in camera streams or switching to another camera. One way to test our attentional and perceptual abilities during observation of dynamic footage is to implement a change detection paradigm. This allows researchers to ascertain whether observers are missing large changes in their perceptual environment from one view to the next, known in the literature as change blindness (Levin & Simons, 1997).

3.2.3 Change Blindness

Change blindness research has demonstrated that observers typically detect changes to central objects more than changes to marginal objects (Rensink, O’Regan & Clark, 1997). However, there are examples in the published research where changes to central objects have gone undetected (Angelone, Levin & Simons, 2003). The most astonishing example of this involves observers failing to detect the switching of two people during a real-world interaction (see Simons & Levin, 1998). Similarly, Levin, Simons, Angelone and Chabris (2002) demonstrated that 75% of their participants missed a change when the person they were talking to ducked behind a counter and switched with a confederate who stood up and continued the conversation. Angelone et al., (2003) found that when participants failed to detect a change in identity of two central actors in a video, some still went on to select the post-change actor from a line-up.

The present study included both central and marginal changes to people and objects in CCTV footage. The eye movement behaviour, both just before the change and during the change, of change detectors and non-detectors was recorded. Although no specific hypotheses were made, it was anticipated, based on the findings presented in Chapter two, that change detectors would exhibit different eye movement
behaviours directly before and during the critical change period compared to non-detectors.

In summary, this study investigated whether task instructions influenced fixation behaviour as demonstrated in previous research. Central and marginal changes were included to ascertain whether participants fixated more on central events compared to marginal events and finally we compared differences in eye gaze behaviour between change detectors and non-detectors.

3.3 Method

3.3.1 Pilot Study

A pilot study was run as it was important that participants were able to identify that the videos depicted a crime. It was also critical that a portion of the observers were able to identify the changes taking place in the videos in order to avoid floor effects for change blindness.

3.3.1.1 Participants.

Forty undergraduate students participated in the experiment (25 females, 15 males). Participant ages ranged from 18 years to 48 years ($M = 24.50$ years, $SD = 7.45$ years).

3.3.1.2 Materials; CCTV Footage.

Mock CCTV footage was filmed using two JVC Everio digital cameras (model number GZMG750BEK), and the footage was edited using Adobe Premier Pro. Four mock black and white CCTV videos were created after the editing process. Each video was one minute and thirty seconds in duration and alternated every five seconds between two different camera viewpoints showing the interior and exterior of a University building (see Figure 3.2). A crime (see Figure 3.1) took place in each
video, involving a young man being attacked and having his laptop stolen by two criminals outside a university building.

Figure 3.1: The two stills represent the crime that took place in each of the four videos. A male was seen leaving a University building, where two youths had been standing for the duration of the video. The male places down his laptop bag to answer his mobile phone. As he reaches for his phone, one of the youths runs towards him and pushes him into the door whilst the other youth grabs the laptop bag. Both youths run off quickly, leaving the male victim dazed and shocked.

The first video (central person change, see Figure 3.3) featured one of the criminals switching with a different person during a change in camera angle. The second video (central object change, see Figure 3.3) featured a change in an object that the criminals were playing with throughout the video. The colour and style of the football switched during a change in camera angle. The third video (marginal person change, see Figure 3.3) featured a lady, who was sitting on a chair using her mobile phone, switching with a different person during a change in camera angle. The fourth video (marginal object change, see Figure 3.3) featured a change in an object belonging to the lady on the chair. The lady’s laptop bag switched to a smart leather bag during a change in camera angle.
Figure 3.2: Plan view diagram (adapted from Smith, 2010) indicating the layout of the cameras for Study 2.
3.3.1.3 Procedure.

Observers in the pilot test were asked to watch one of the four mock CCTV videos uploaded to an online survey site (PsychSurvey.org). The observers were asked the following questions about the videos: 1. Was there a criminal event taking place in the video (if yes, please describe it)? 2. Did you notice any changes in the video (if yes, describe them)? 3. Any general comments?

3.3.1.4 Results.

Piloting confirmed that the videos were regarded suitable for the main experiment as 100% of the observers identified that a crime took place. Moreover, 45% of the participants detected the central person change and 35% detected the marginal person change. However, only one participant detected the central object change.
change and no-one detected the marginal object change. The decision was made to only use the central and marginal person change videos due to so few participants detecting the marginal (object) changes. We decided to keep the instructions to ‘Focus on people’ and ‘Focus on objects’ in the main experiment to test whether those who were specifically asked to focus on people were better able to detect the change in identity of the central or peripheral character (compared to those who were asked to focus on objects).

3.3.2 Main study
3.3.2.1 Participants.
Seventy-six participants took part in the experiment (46 females, 30 males), ranging in age from 18 to 66 years ($M = 26.7$ years, $SD = 9.98$ years). The participants consisted of undergraduate students and staff at the University of Portsmouth. Psychology students and staff were not permitted to complete the study due to potential prior knowledge of change blindness and expectations of the nature of the study.

3.3.2.2 Design.
Instruction (“Focus on people” or “Focus on objects”) and Change location (Central change or Marginal change) were between subjects factors. The dependent variables were two measures of eye movements: fixation count (the number of fixations on the targets) and fixation duration (total time of each fixation on targets measured in milliseconds).

Change detection was initially treated as a dependent variable in terms of the effect of Instruction and Change location on whether or not participants spotted the change in the CCTV footage. Change detection was recorded, for each condition, as the percentage of participants who correctly spotted the change. In subsequent
analyses change detection was used as a predictor variable to ascertain whether or not fixation behaviour predicted change detection.

3.3.2.3 Materials.

The videos were presented on a computer monitor. A second computer, used to control the eye tracker, was linked to the computer presenting the videos. The video-based EyeLink 1000 (SR Research, Ltd, Osgoode Canada) was used to record participants’ eye movements, and was run at 1000 Hz while tracking both pupil and corneal reflection. A chin-rest was used to maintain the participants’ viewing position of 50 cm from the computer monitor.

3.3.2.4 Procedure

After obtaining informed consent from participants the measurements of the eye-tracker were calibrated using a nine point grid. Calibration was repeated, if necessary, until predicted and actual fixation position differed by no more than 0.5˚.

Participants were randomly allocated to watch one of two videos; they either watched the central person change or the marginal person change (see Figures 3.2 and 3.4 above). Participants were also randomly assigned to one of the two instruction conditions. Those in the “Focus on people” condition were told “Please watch the following video and focus on the people in the footage”. Those in the “Focus on objects” condition were told “Please watch the following video and focus on the objects in the footage.” The instruction appeared on the screen before the video played. Participants were given as much time as they needed to read the instruction before clarifying to the experimenter that they understood and were happy to proceed. When the participants were happy with their instructions they watched a video clip. Eye tracking was stopped once the video finished.
After the experiment, participants were asked to complete a questionnaire (see Appendix 2.1) to identify whether or not they detected the change. If participants stated that they identified a change, they were asked to provide a description of this along with rating how confident they were that they saw the change. Participants were told that they had as much time as they required for answering the questions. Participants were then fully debriefed. Each testing session lasted approximately 20 minutes.

3.3.2.5 Data Screening.

Fixation durations were only included if they were 100 ms or longer. Raw eye movement data was analysed using Dataviewer (SR Research, Ltd, Osgoode Canada) software. The videos were edited down to two key stages for analysis; the five seconds immediately before the critical change period and the five second critical change period in which each change took place. We distinguish the period before the change as follows; participants either witnessed a change outside (central) or inside (marginal) the building. Throughout the duration of the video, participants witness 5 seconds from the outside camera before it switches to the inside camera for 5 seconds. This pattern continues until the end of the video. We categorise the before change period as the last view participants have of either the outside or inside. Therefore, participants in the outside change condition will view the outside shot before the camera switched to the inside. The next time the view goes back to the outside, the perpetrator has switched with another person. Therefore, it is the last view from the outside camera before the change period that is identified as the before change period. The same concept applies to the inside change, with the last view of the inside camera before the change period being identified as the before change period.
Figure 3.4 illustrates the timings for the central person change. Figure 3.5 illustrates the timings for the marginal person change. Fixation count and fixation duration on target served as the dependent variables. The targets were defined as the people whose identity changed during the course of the videos.

Figure 3.4: Stills from the central person change video with time stamps from the video in minutes and seconds. Still a. demonstrates the last view of the central location 5 seconds before the change took place. Still b. shows the changed camera view to the marginal location for 5 seconds. When the camera returned outside, as depicted in still c., there had been a switch in person in the central location (the man holding the football).

Figure 3.5: Stills from the marginal person change video with time stamps from the video in minutes and seconds. Still a. demonstrates the last view of the marginal location 5 seconds before the change took place. Still b. shows the changed camera to the central location for 5 seconds. When the camera returned inside, as depicted in still c., there had been a switch in person in the marginal location (the woman on the chair).
3.4 Results

3.4.1 Change Detection

Twenty-six out of 76 participants detected changes. Chi-square tests were performed to see if change location and instruction were associated with change detection. There was a relationship between change location and change detection, $X^2 (1, N = 75) = .111, p = .003$. Out of the 26 change detectors, 19 detected the central change (the switch in identity of one of the offenders) compared to 6 who detected the marginal change (the switch in identity of the lady inside the building). No relationship was found between instruction and change detection, $X^2 (1, N = 75) = .000, p = .231$. That is, it made no difference whether participants were asked to focus on objects or focus on people in terms of whether or not they detected a change.

3.4.2 Eye Movement Results

3.4.2.1 Before Change.

A MANOVA was conducted with Instruction (“Focus on People” v “Focus on Objects”) and Change location (“Central” v “Marginal”), as the independent variables and number of fixations on target (fixation count) and fixation duration in the 5 seconds before the critical change as the dependent variables (see Figure 3.7).

The MANOVA revealed no significant multivariate main effect of Instruction, Wilks’ $\lambda = .992, F (2, 71) = .27, p = .764$, partial $\eta^2 = .008$. In addition, no significant univariate main effects for Instruction were obtained for fixation count, $F (1, 76) = .45, p = .507$, partial $\eta^2 = .006$, or fixation duration, $F (1, 76) = .27, p = .605$, partial $\eta^2 = .004$. Therefore, providing instructions directly before observing the CCTV footage did not influence fixation behaviour directly before the change period.
The MANOVA revealed a significant multivariate main effect for Change location, Wilks’ $\lambda = .775$, $F(2, 71) = 10.28$, $p < .001$, partial $\eta^2 = .225$. Follow-up univariate analyses revealed a significant main effect of Change location on fixation count, $F(1, 76) = 18.82$, $p < .001$, partial $\eta^2 = .207$, with more fixations being made toward the central target ($M = 2.53$, $SD = 2.71$, 95% CI [1.70, 3.37]) compared to the marginal target ($M = .47$, $SD = 1.01$, 95% CI [.18, .83]). There were also significantly longer fixation durations, $F(1, 76) = 20.83$, $p < .001$, partial $\eta^2 = .224$, on the central target ($M = 932$ ms, $SD = 957.77$, 95% CI [630.35, 1225.54]) compared to the marginal target, ($M = 169.18$ ms, $SD = 351.49$, 95% CI [72.60, 294.58]). Therefore, participants fixated more often and for longer on the Central target compared to the Marginal target in the CCTV footage directly before the change. The MANOVA revealed no significant multivariate interaction effect of Instruction and Change Location, Wilks’ $\lambda = .995$, $F(12, 71) = .16$, $p = .852$, partial $\eta^2 = .005$.

Although no specific hypotheses were made, a simple linear regression was calculated to ascertain whether fixation count immediately before the change took place was a predictor of change detection. A significant regression equation was found, $F(1, 74) = 9.88$, $p = .002$, with an $R^2$ of .118. Participant’s predicted Change detection was equal to $.234 + .072$ fixations (number of fixations). A simple linear regression was also calculated to ascertain whether fixation duration immediately before the change took place was a predictor of change detection. A significant regression equation found, $F(1, 74) = 10.95$, $p < .001$, with an $R^2$ of .129. Participant’s predicted Change detection was equal to $.226 + .000$ fixation duration (in msec). Therefore, these results are consistent with a pattern indicating that more and longer fixations just before the change period predicted change detection.
3.4.2.2 Critical Change Period.

A MANOVA was conducted with Instruction (“Focus on People” v “Focus on Objects”) and Change location (“Central” v “Marginal”) as the independent variables and number of fixations on targets (fixation count) and fixation duration during the 5 second critical change period as the dependent variables.

The MANOVA revealed no significant multivariate main effect of Instruction, Wilks’ λ = .955, $F(2, 71) = 1.68, p = .193$, partial $\eta^2 = .045$. In addition, no significant univariate main effects for Instruction were obtained for fixation count, $F(1, 76) = 1.23, p = .272$, partial $\eta^2 = .017$, or fixation duration, $F(1, 76) = .13, p = .722$, partial $\eta^2 = .002$. Therefore, providing instructions directly before observing the CCTV footage did not influence fixation behaviour during the change period.

The MANOVA revealed a significant multivariate main effect for Change location, Wilks’ λ = .676, $F(2, 71) = 16.99, p < .001$, partial $\eta^2 = .324$. Follow-up univariate analyses revealed a significant main effect of Change location on fixation count, $F(1, 76) = 34.35, p < .001$, partial $\eta^2 = .323$, with more fixations being made toward the central target ($M = 5.05, SD = 3.15, 95\% \text{ CI}[4.11, 6.07]$) compared to the marginal target ($M = 1.29, SD = 2.36, 95\% \text{ CI}[.60, 2.10]$). Participants also fixated significantly longer, $F(1, 76) = 26.34, p < .001$, partial $\eta^2 = .268$, on the central target ($M = 1652.82 \text{ ms}, SD = 1071.27, 95\% \text{ CI}[1316.74, 2003.86]$), compared to the marginal target, ($M = 475.82 \text{ ms}, SD = 911.45, 95\% \text{ CI}[205.30, 793.63]$). Therefore, participants fixated more often and for longer on the Central target compared to the Marginal target in the CCTV footage during the change. The MANOVA revealed no significant interaction effect of Instruction and Change location, Wilks’ λ = .942, $F(2, 71) = 2.19, p = .119$, partial $\eta^2 = .058$. 
Although no specific hypotheses were made, a simple linear regression was calculated to ascertain whether fixation count immediately before the change took place was a predictor of change detection. A significant regression equation was found, $F(1, 74) = 34.27, p < .001$, with an $R^2$ of .317. Participant’s predicted Change detection was equal to $0.88 + 0.080$ fixations (number of fixations). A simple linear regression was also calculated to ascertain whether fixation duration immediately before the change took place was a predictor of change detection. A significant regression equation found, $F(1, 74) = 31.45, p < .001$, with an $R^2$ of .298. Participant’s predicted Change detection was equal to $0.102 + 0.000$ fixation duration (in msec). Therefore, these results are consistent with a pattern indicating that more and longer fixations during the critical change period predicted change detection.

### 3.5 Discussion

We examined the eye movements of participants, who were given varying instructions, whilst watching CCTV footage that depicted a crime. A change detection paradigm was included, involving the switching in identity of the one of the criminals (central change) and a bystander (marginal change) during a cut in camera angle. Specifically, we were interested in three main issues. First, we examined how task specific instructions influenced where people attended to in a dynamic scene with a large array of factors competing for attention. Second, we examined whether central or marginal information influenced eye movements. Third, we examined whether eye movements were predictors of change detection.

#### 3.5.1 The Influence of Task Instructions on Fixation Behaviour

We predicted that having specific instructions (to focus on people or focus on objects) would influence fixation behaviour during CCTV observation. However, overall, there was no effect of instructions on fixation behaviour. Our prediction was
based on the assumption that although relatively little is known about the role of task
goals on eye movements during real-world dynamic visual search, previous research
has suggested that observers fixate on areas of the scene that are relevant to their task
(Howard et al., 2011). However, the results of the present study did not support the
findings of this previous research.

The present results were however consistent with those found in Chapter two,
which demonstrated no effect of three different instructions (detect crime, detect
anything unusual, or simply watch the footage) on fixation behaviour. Research of this
nature is limited in that there is surprisingly little known about the role of task
instructions on eye movement behaviour during dynamic visual search (Howard et al.,
2011). Furthermore, current models of fixation behaviour are based solely on static
scene or picture viewing paradigms, leading to difficulties generalising these models
to interpret dynamic stimuli (Tatler et al., 2011).

It is possible that the instructions provided to participants were not detailed or
specific enough. Karns and Rivardo (2010) gave participants a folder of information
about a target person who participants had to search for on CCTV footage. This may
have led to a greater reliance on top-down processing as detailed information was
provided prior to observation of the footage. Also, in real-world CCTV surveillance,
operators can request information when tracking a suspect. For example, a CCTV
operator may ask police on the ground to describe the clothes the suspect is wearing.
This makes the task goal clearer and the visual information easier to detect. Future
experimental research should manipulate the way in which instructions are provided
to CCTV operators (i.e. giving a detailed description of the clothes the suspect is
wearing) to see whether this has an impact on gaze behaviour. For example, the level
of detail included in instructions could be manipulated to see whether there is a
minimum level of detail required in order to influence CCTV operators’ observation strategies.

3.5.2 Central and Marginal Changes

We predicted that observers would fixate more and for longer on a target in a central location compared to a target in a marginal location. This prediction was supported as participants fixated more and for longer on central information (the offender) in the footage compared to marginal information (the woman sitting talking on her phone). The results support previous findings showing that participants recalled more accurate central, as opposed to peripheral, details about a cycling accident (Christianson et al., 1991). Similarly, participants fixate on objects of central interest more often than objects of marginal interest during the observation of driving videos (Underwood et al., 2003).

We looked at two specific time frames in terms of gaze behaviour. The first was directly before the change took place and the second was just as the change took place. Even before the change and subsequent crime took place in the footage, participants were fixating on the central target more than the marginal target. Land (2006) stated that, in real-world visual search tasks, our eyes act in a proactive way, typically seeking out the information required directly before each act commences. The same idea can be applied to understanding events in CCTV footage. That is, as Baldwin and Baird (2001) argued, observers are trying to understand the underlying intentions of the people and anticipating future actions, particularly of a criminal nature. Therefore, the observers in the present study may have fixated for longer on central target (the perpetrator), as they attempted to understand his intentions and anticipating if anything criminal is about to occur.
An important implication derived from the results of this study is the lack of attention directed towards marginal information in the footage compared to central information. The marginal target was a woman sitting on a chair talking on her mobile phone. Whereas the central target was a young male pacing back and forth outside of a building. Mital, Smith, Jill and Henderson (2011) found that observers attend to areas of high motion in a dynamic scene. This is likely to be the case because it gives the viewer visual cues (i.e. someone running towards another person) to aid their understanding of the unfolding event. It may be the case, for the current study, that the lack of motion by the marginal target caused participants to direct their attention towards suspicious behaviour in the form of the central target. With multiple events potentially taking place at once during CCTV footage (e.g. the London Riots, 2011) or events occurring in the periphery of the screen, we need a better understanding of how we can optimally search all aspects of the footage to avoid missing crucial information. One way of doing this is to test expert CCTV operators in the same conditions to see how often they fixate on both central and marginal detail. Underwood et al. (2003) found that experienced drivers recalled more incidental details than the novice drivers, suggesting that there may by an effect of expertise.

Consistent with previous change blindness research (e.g. Levin & Simons, 1997), only 34.2% of the participants detected changes in the footage. Results showed that change location influenced change detection, with 19 participants detecting the central change compared to just 6 participants detecting the marginal change. Fixation behaviour was also a predictor of change detection, with change detectors producing more and longer fixations on the targets directly before and during the critical change period.
The results support previous change blindness research that found that participants typically detect changes to central objects more often than changes to marginal objects (Rensink et al., 1997), with more participants detecting central person changes marginal person changes. Our findings also reflect the work of Simons and Levin (1998) and Simons et al., (2002), whose participants missed two people switching places. The difference in our study was that our participants were watching CCTV footage rather than interacting face-to-face with the changing target. Regardless, there are huge implications if CCTV operators miss crucial information in the footage they watch, whether they be central or marginal changes.

Although no directional hypotheses were made, it was anticipated that change detectors would produce a different pattern of fixation behaviour compared to non-detectors. Directly before the change took place, change detectors fixated more on the central, changing target than the non-detectors. These results are similar to those reported in Chapter two that change detectors fixated more on the changing target directly before the change compared to non-detectors. As well as replicating that finding in the current study, we also found that change detectors fixated on the target for longer durations directly before the change. Kuhn, Tatler, Findlay and Cole (2009) found that during the presentation of a magic trick, participants who detected the sleight of hand moved their eyes towards where it took place much earlier than participants who missed it. Therefore, the participants in the current study may have anticipated an event occurring, which was reflected in their fixation behaviour. These findings also support previous research that has found that anticipatory eye movements may fall on people / targets associated with a task goal (e.g. Pelz & Canosa, 2001).
Change detectors also fixated more and for longer as the central change took place compared to when the marginal change took place. Change detectors also fixated more and for longer than non-detectors as the central change took place. As the central change took place, the central target person attacked and stole a laptop from a man leaving a building. Therefore, the severity and emotive nature of the crime would have captured the observers’ attention, with a portion of participants going on to detect the change. We know that participants fixated more on the central information (compared to the marginal information) during the change period. Despite this, a large proportion of participants still miss the change to the central target (the offender). One explanation is that they decided to focus their attention on the victim of the crime as opposed to the perpetrator. No study to date has eye tracked observers to see if they focus their attention more towards the criminal or the victim whilst witnessing criminal events. This could provide rich fixation data regarding where we attend to during criminal events.

3.5.3 Conclusion

In summary, the present study investigated whether task instructions influenced fixation behaviour as demonstrated in previous research. Central and marginal changes were included to investigate whether participants fixated more on central information compared to marginal information. In turn, we wanted to determine whether fixation behaviour influenced change detection. There was no effect of instructions on fixation behaviour. That is, it made no difference to eye behaviours whether participants were instructed to focus on objects or persons. However, participants fixated more and for longer on the central target in the footage compared to marginal target. Furthermore, change location influenced change detection, with more participants detecting a central change compared to detecting a
marginal change. Fixation behaviour was a predictor of change detection, with change
detectors producing more and longer fixations on the targets directly before and
during the change compared to non-detectors. These results demonstrate clear fixation
behaviour differences between change detectors and non-detectors. This study also
demonstrated the complexities of dynamic visual search compared to static visual
search and highlighted potential attentional and perceptual limitations during CCTV
observation.

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Chapter 4: Experiments 3a and 3b: Investigating Memory Recall of CCTV Footage using an Applied Change Detection Task

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4.1 Abstract

It is only recently that the accuracy of memory recall has been investigated alongside the change blindness phenomenon in forensic contexts. In Experiment 3a, 147 participants watched Closed-Circuit Television (CCTV) footage during which a criminal event did, or did not take place and were instructed to (i) detect crime, (ii) detect anything unusual or (iii) watch with no instruction. During the events there was a change which comprised a switch in location for two people. Findings supported the prediction that those watching the criminal event would recall more accurate detail than those watching the non-criminal event. However, contrary to expectations, there was no effect of instruction on recall accuracy and no difference in the amount of accurate detail recalled between the change detectors and non-detectors. That said, non-detectors recalled significantly more inaccurate information than detectors. In Experiment 3b, 76 participants witnessed CCTV footage of a crime that was more severe than that depicted in experiment one. The location of the change was also manipulated; it was either central or marginal to the main action of the event. This time, change detectors recalled more accurate details compared to non-detectors, but there was no effect of the location of the change on recall accuracy. This research is important from a forensic perspective as it highlights limitations in memory recall and how observers attend to CCTV footage, both of which are relied upon as evidence in court.

4.2 Experiment 3a: Introduction

In the early hours of the 25th January 1995, US police officer Kenny Conley scaled a fence in order to chase a suspect. Moments before, an undercover police officer called Michael Cox arrived on the scene but was mistaken by other police officers as the suspect and was brutally assaulted by his colleagues. Conley, after
chasing and arresting the suspect, claimed he must have run right past the assault on Cox but did not see anything. Conley’s eyewitness testimony was criticised in court as it was assumed that as he *could* have seen the assault, he *should* have seen it and was therefore lying in order to protect his colleagues. Conley was sentenced to thirty-four months in jail for perjury and obstruction of justice (Chabris, Weinberger, Fontaine & Simons, 2011).

The scenario depicted above is an example of inattentional blindness, which is the failure to perceive an unexpected object or event as a result of attention being diverted elsewhere (Simons & Chabris, 1999). One of the classic lab-based studies of inattentional blindness by Simons and Chabris (1999) involved participants watching two different teams passing a basketball to each other. Participants were asked to count the number of passes made between team members wearing white t-shirts and team members wearing black t-shirts. In the video, a person wearing a gorilla suit walked through the scene. Approximately half of the participants failed to notice the gorilla in the scene. This is referred to as inattentional blindness. Similar to inattentional blindness is the notion of change blindness which refers to observers missing changes to objects or people when one view of a scene switches to another and then back to the original (Levin & Simons, 1997). Inattentional blindness differs from change blindness in that participants fail to notice the appearance of an unexpected item (Simons & Chabris, 1999). With both inattentional and change blindness, we fail to notice something that is distinctly visible (Jensen, Yao, Street & Simons, 2011). Furthermore, research has demonstrated that we fail to detect changes even when we know to look for them and are confident in our ability to detect them (see Levin, Momen, Drivedahl & Simons, 2000). Importantly, these two phenomena both illustrate failures in visual awareness.
Chabris, et al., (2011) developed a lab based study that emulated the real world Conley case (as described above). They investigated whether participants would notice a fight taking place whilst running after a confederate. Only 35% of participants noticed the fight at night, with 56% noticing during the day. These findings highlighted, using a controlled experimental setting, limitations relating to eyewitness memory recall. Chabris et al., (2011) used a ‘live’ event in their study, representing a potential criminal event that would be monitored remotely via CCTV. By necessity, a CCTV system must flick between multiple views of a complex scene to try to capture as much information as possible. Therefore, the average CCTV system can be considered a ‘change blindness’ machine, leading to the possibility that crucial information may be missed (Scott-Brown & Cronin, 2007). Little research, to date, has examined this possibility.

CCTV is often used in police investigations and relied upon in court (Davis & Valentine, 2009). However, very little is known about the strategies that observers use when interpreting, attending to, and recalling (criminal) events observed in such footage (see Chapter 2 and 3). In real-world CCTV surveillance, it is the case that observers spend a lot of time anticipating that a crime will take place whilst they watch footage which, in fact, may contain no criminal activity at all. Observers may rely on cues from the footage to help them understand what is happening (bottom-up processing) or they may rely on their expectations about what might happen or what they have been instructed to look for (top-down processing) (Grant & Williams, 2011). In terms of bottom-up processing, Troscianko et al., (2011) found that observers effectively predicted the onset of criminal behaviour by selecting targets based on their body position and gestures in the CCTV footage. However, Norris and Armstrong (1999) suggested that targets can be successfully selected for surveillance
due to top down processing (i.e. based on preconceptions of a likely offender and pre-existing crime-related beliefs). In the real world, it is likely that both bottom-up and top-down processes happen concurrently (Grant & Williams, 2011).

In the current chapter two experiments are reported that used a change blindness paradigm to investigate how accurately observers could recall information from Closed-Circuit Television (CCTV) footage.

4.2.1 The Role of Type of Event and Instructions

The present study introduced experimental manipulations to test the extent to which both bottom-up and top-down processing influenced eyewitness recall of CCTV footage. In terms of bottom-up processing, participants either watched a criminal event or non-criminal event. As a crime begins, it is likely that observers’ attention is focussed on aspects of the footage associated with the crime (e.g. the criminal). If no crime takes place it is likely that observers do not focus their attention to such an extent (see Chapter 2; Howard, Gilchrist, Troscianko, Behera & Hogg, 2011). As such, we predicted that participants watching footage containing the criminal event would recall more accurate details compared to those watching footage without a criminal event.

In terms of top-down processing, there is a large literature investigating how instructions and task goals influence the way in which observers attend to scenes (e.g. Castelhano, Mack, & Henderson, 2009). Evidence from dynamic real-world visual search tasks demonstrates that observers fixate on task-relevant objects rather than the most visually salient objects (Tatler & Tatler, 2013). In a forensic context, Howard et al., (2011) found that task-relevance determined where observers attended whilst watching CCTV footage. Participants fixated more often on suspicious behaviour only after being instructed to do so. This example of top-down processing demonstrates
that observers attend to features of CCTV footage based on expectations of what they deem to be suspicious behaviour.

Instructions have also been shown to impact upon attentional set. Attentional set relates to the way individuals prioritise what they look at based on task-goals to aid efficient visual search (Leber & Egeth, 2006). For example, if we are searching for car keys, which have a distinctive pink key ring attached to them, we will focus our entire visual search on looking for anything coloured pink. Karns and Rivardo (2010) wanted to test attentional set relating to the actions of a target person on CCTV footage. Half of their participants received information, prior to search, that the target person had a restraining order against him. The other half of the participants were told that the target person had to attend a family emergency. Half of the participants watched footage that included a confrontation whilst the others watched footage that included a person, wearing a gorilla suit, walking across the frame. Participants were unaware that each unexpected event (confrontation and gorilla) would take place in the footage. Those who were told that the target person had a restraining order against him noticed the confrontation (77%) more than the man in the gorilla suit (40%). Those looking out for a target on his way to a family emergency noticed the man in the gorilla suit (77%) more than the confrontation (71%). Therefore, the instructions provided before the task effected what captured the participants’ attention whilst observing the footage.

In the present study, we examined how providing specific instructions affected the way observers attended to CCTV footage and in turn, impacted their ability to recall details from the footage. We predicted that those instructed to detect crime would recall more accurate details than those instructed to look for ‘something unusual’ and those instructed to simply watch the video with no specific focus.
4.2.2 Change Detectors and Memory Recall

Psychological research has demonstrated how people often fail to notice significant changes in their environment (Scott-Brown & Cronin, 2007). This clearly has implications for a forensic context if, for example, eyewitnesses fail to detect changes and then go on to report inaccurate information at interview, or in court (Laney & Loftus, 2010). For example, Davies and Hine (2007) asked participants to observe footage of a staged burglary. The identity of the burglar was changed halfway through the footage. Consistent with previous change blindness research, a large number of participants failed to detect the change in identity of the burglar (61%). However, participants who went on to detect the change provided more accurate information about the footage than those who failed to detect the change. Nelson et al., (2010) found that participants were more likely to falsely identify an innocent bystander as a criminal if they witnessed a video designed to induce change blindness compared to those who viewed control videos which included no changes. Similarly, Fitzgerald, Oriet and Price (2011) found that participants who detected changes to faces in a line-up study were more confident in a later test of their recognition memory.

The findings from the limited studies that have integrated change blindness and eyewitness memory have found that change detectors provide more accurate testimony than non-detectors. However, very few studies have examined the potential mechanism(s) underlying this effect. For example, the study presented in Chapter 2 investigated eye movement differences between change detectors and non-detectors during CCTV observation. They found that change detectors fixated their eye movements on the changing target directly before the change took place significantly more often than the non-detectors. This research identified eye movement behaviours
that change detectors adopted during CCTV observation which were absent for non-detectors. Based on the previous research outlined above, we predicted that change detectors would recall more overall accurate details than non-detectors.

4.3 **Experiment 3a: Method**

4.3.1 **Participants**

One hundred and forty-seven participants took part in the experiment (91 females, 56 males) who ranged from 18 to 50 years of age ($M = 29.62$ years, $SD = 6.91$ years). The participants consisted of undergraduate students and staff at the University of Portsmouth. Psychology students and staff were not permitted to complete the study due to potential prior knowledge of change blindness and expectations of the nature of the study.

4.3.2 **Design**

Event type (“Criminal” or “Non-criminal”), Instruction (“Detect Crime”, “Detect Anything Unusual”, or No Instruction) and Change detection (“Detectors” or “Non-Detectors”), constituted between-subjects, independent variables. The dependent measures were the number of accurate, inaccurate and confabulated event details recalled by participants.

4.3.3 **Materials**

Mock CCTV footage was filmed using two JVC Everio digital cameras (model number GZMG750BEK), and the footage was edited using Adobe Premier Pro. Each event (Criminal and Non-criminal) was two minutes in length and alternated every five seconds between two different camera viewpoints showing different parts of a doctor’s waiting room. The footage was black and white and featured six people entering, sitting and leaving the waiting room of the surgery. The Criminal and Non-criminal events were identical except for a five second segment. In that segment, the
Criminal event included the theft of a mobile phone (in the Non-criminal event this theft did not take place). During the Criminal event, a male stole a phone that was left on one of the chairs. In the Non-criminal event, the owner of the phone left it behind but returned to collect the phone from the chair (see Figure 4.1).

![Criminal event](image1.png) ![Non-criminal event](image2.png)

Figure 4.1: The still of the Criminal event shows the male picking up the phone that has been left by the lady exiting the seated area. The male proceeds to place the phone in his pocket. In the Non-criminal still, the lady returns to collect her phone after realising she has dropped it. No crime is committed.

Halfway through the event (for the Criminal and Non-criminal conditions), two seated males (targets) switched location during a change in camera position. One of these targets was the criminal. Their positions stayed the same for the remainder of the video (see Figure 4.2).
4.3.4 Procedure

Each participant was randomly allocated to watch one of the two minute events (Criminal or Non-criminal). Participants were also randomly assigned to one of the three instruction conditions (“Detect Crime”, “Detect Anything Unusual”, or No Instruction). The instruction for the “Detect Crime” participants was: “Please watch the following video and look out for any crime”. The instruction for the “Detect Anything Unusual” participants was: “Please watch the following video and look out for anything unusual”. The instruction for the No Instruction participants was: “Please watch the following video”. The instruction appeared on the screen before the video.
was played. Participants were given as much time as they needed to read their particular instruction before clarifying to the experimenter that they understood and were happy to proceed. Participants then watched the video.

After watching the video, participants completed a questionnaire (see Appendix 2.1) measuring eyewitness memory recall as well as establishing whether they detected the change in location of the two target males. Participants were asked the following questions: 1. Can you please describe what you observed in the video? 2. Did you see anything change in the video? If so, please describe it below. They gave open ended responses (free narrative) to each of these questions. The length of their answers was not constrained in terms of space or length of time allowed for completion of the questionnaire.

4.3.5 Coding

Participant responses to question one (free narrative description of the event) were coded by an independent rater into the following categories: accurate, inaccurate and confabulated detail (see Akehurst, Milne & Koehnken, 2003). If participants successfully reported a detail correctly from the CCTV footage, it was coded as ‘accurate’. For example, “the man had a dark jumper on” constituted three accurate details for “man”, “dark” and “jumper”. If participants incorrectly reported a detail from the footage, it was coded as ‘inaccurate’. For example if a participant reported that the man was wearing a white jumper, “white” was coded as one inaccurate detail. If participants recalled a detail that did not feature in the footage, it was coded as ‘confabulated’. For example, if a participant reported that the man was wearing a jacket, “jacket” was coded as one confabulated detail (because no men in the footage were wearing jackets). A second rater independently coded 20% of the responses. Inter-rater reliability was assessed using the percentage agreement method. For
accurate details the raters agreed 92% of the time, for inaccurate details they agreed 92% of the time and for confabulated details they agreed 100% of the time. With these high percentage agreements, the first rater’s codes were used for the remainder of analyses.

The answers to question two were used to classify participants as Change detectors or Non-detectors. If they accurately identified the change (i.e., that the males had switched positions in the doctor’s waiting room) they were labelled Change detectors, otherwise they were labelled Non-detectors.

4.4 Experiment 3a: Results

A MANOVA was conducted with Event type (“Criminal” or “Non-criminal”) and Instruction (“Detect crime”, “Detect anything unusual” or “No instruction”) as the independent variables and the number of accurate, inaccurate and confabulated event details as the dependent variables. The MANOVA revealed a significant multivariate main effect for Event type, Wilks’ λ = .913, $F (3, 142) = 4.50, p < .005$, $\eta^2 = .087$. At a univariate level, there was a significant effect of Event type on accurate event detail, $F (1, 150) = 12.73, p < .001$, $\eta^2 = .081$. Observers watching the Criminal event reported more accurate event detail ($M = 18.71, SD = 8.07, 95\% CI [16.84, 20.62]$) than those watching the Non-criminal event ($M = 14.29, SD = 7.17, 95\% CI [12.81, 15.99]$. No significant univariate main effects for Event type were obtained for inaccurate or confabulated detail (see Table 4.1).

There was no significant multivariate main effect of Instruction, Wilks’ λ = .943, $F (6, 284) = .141, p = .208$, $\eta^2 = .029$. The Event type x Instruction interaction effect was not significant, Wilks’ λ = .917, $F (6, 284) = 2.086, p = .055$, $\eta^2 = .042$ (see Table 4.2).
Of the 147 participants tested, only 36 (24.5%) detected the change in seating position of the two target males. These data allowed for a division of the participants into Change Detectors and Non-Detectors. As the number of Detectors was relatively low, this variable was considered separately in order to address the prediction that change detectors would recall more accurate event detail than non-detectors.

A one-way ANOVA was conducted with Change detection (Change detectors or Non-detectors) as the independent variable and accurate, inaccurate and confabulated event detail as the dependent variables. The ANOVA revealed a significant effect of Change detection on inaccurate details, $F(1, 149) = 7.946, p < .005$, $\text{partial } \eta^2 = .051$, with Non-detectors reporting more inaccurate details ($M = .42, \text{SD} = .704, 95\% \text{ CI } [.29, .55]$) than the Change detectors ($M = .08, \text{SD} = .277, 95\% \text{ CI } [.00, .18]$). There was no significant difference between Change detectors on the number of accurate and confabulated details recalled (see Table 4.3).
Table 4.1  MANOVA results for each of the dependent variables for the Event type conditions

<table>
<thead>
<tr>
<th></th>
<th>Criminal event</th>
<th>Non-criminal event</th>
<th>F</th>
<th>p</th>
<th>Partial eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accurate Details</td>
<td>18.71 (8.07)</td>
<td>14.29 (7.17)</td>
<td>12.73</td>
<td>.001*</td>
<td>.081</td>
</tr>
<tr>
<td>Inaccurate Details</td>
<td>.35 (.65)</td>
<td>.32 (.64)</td>
<td>.07</td>
<td>.795</td>
<td>.000</td>
</tr>
<tr>
<td>Confabulated Details</td>
<td>.07 (.30)</td>
<td>.13 (.50)</td>
<td>.98</td>
<td>.324</td>
<td>.007</td>
</tr>
</tbody>
</table>

*p < .005
Table 4.2  MANOVA results for each of the dependent variables for the Instruction conditions

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Detect crime Mean (SD)</th>
<th>Detect Unusual Mean (SD)</th>
<th>No Instruction Mean (SD)</th>
<th>$F$</th>
<th>$p$</th>
<th>Partial eta$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate Details</td>
<td>15.72 (7.25)</td>
<td>15.28 (6.51)</td>
<td>18.50 (9.49)</td>
<td>2.66</td>
<td>.074</td>
<td>.036</td>
</tr>
<tr>
<td>Inaccurate Details</td>
<td>.28 (.57)</td>
<td>.32 (.68)</td>
<td>.40 (.67)</td>
<td>.47</td>
<td>.624</td>
<td>.007</td>
</tr>
<tr>
<td>Confabulated Details</td>
<td>.18 (.63)</td>
<td>.06 (.24)</td>
<td>.06 (.24)</td>
<td>1.41</td>
<td>.247</td>
<td>.019</td>
</tr>
<tr>
<td></td>
<td>Change Detectors Mean (SD)</td>
<td>Non-Detectors Mean (SD)</td>
<td>F</td>
<td>p</td>
<td>Partial eta²</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>---------------------------</td>
<td>-------------------------</td>
<td>-------</td>
<td>-------</td>
<td>--------------</td>
<td></td>
</tr>
<tr>
<td>Accurate Details</td>
<td>15.81 (7.26)</td>
<td>16.73 (8.15)</td>
<td>.37</td>
<td>.544</td>
<td>.002</td>
<td></td>
</tr>
<tr>
<td>Inaccurate Details</td>
<td>.08 (.28)</td>
<td>.42 (.70)</td>
<td>7.95</td>
<td>.005*</td>
<td>.51</td>
<td></td>
</tr>
<tr>
<td>Confabulated Details</td>
<td>.11 (.52)</td>
<td>.10 (.38)</td>
<td>.019</td>
<td>.891</td>
<td>.000</td>
<td></td>
</tr>
</tbody>
</table>

*p < .005
4.5 Experiment 3a: Discussion

In line with predictions, participants recalled more accurate details from the criminal event than the non-criminal event. This supports the explanation that those observing the crime allocated greater attention in order to understand the unfolding event (see Chapter 2). This finding also suggests that observers attended to cues from the footage that related to the criminal event (bottom-up processing, Grant & Williams, 2011).

We predicted that providing participants with specific instructions to detect a crime would influence how they searched though CCTV footage and would in turn increase the amount of accurate detail they recalled. This prediction was based on previous research demonstrating that providing instructions to participants effects how they attend to surveillance footage (Karns & Rivardo, 2010). However, the results showed that instructing participants to detect a crime, detect anything unusual, or simply watch the footage resulted in no significant difference in accurate recall of event details.

A change detection paradigm was used for the current experiment, involving the switching of location of two targets during a cut in camera angle. Nearly one quarter of all participants spotted the change, a figure that is comparable with other change blindness research (see Levin & Simons, 1997). We predicted that the change detectors would recall more accurate details compared to non-detectors. However, there was no significant difference in the amount of accurate event recall between the two groups. This was initially surprising as previous research has found that change detectors produce more accurate recall/identifications (e.g. Davies & Hine, 2007) than non-detectors. However, it is possible that having the change taking place concurrent with the start of the crime, as was the case for those participants who watched the
crime event, may have caused participants to miss the change (i.e. participants may have been looking at the victim or the phone being stolen instead of the criminal, who is also the changing target). In turn, this resulted in less change detectors overall recalling accurate information from the footage. It should be noted that non-detectors reported significantly more inaccurate detail than detectors and this findings should be followed up in future research.

In sum, for Experiment 3a, it appears that bottom up processing (event type) was more influential in terms of attention to detail and accurate recall than top down processing (instruction type). That is, in this experiment, attending to an unfolding event focussed attention and helped accurate recall of the event more than searching through footage as a result of specific top-down instructions given prior to observing the footage (see Most, Scholl, Clifford, & Simons, 2005). These findings informed the design of Experiment 3b which investigated whether the location of a change might play a role in both successful change detection and accurate eyewitness recall. Furthermore, we used a criminal event as it elicited more overall accurate recall in Experiment 3a compared to less accurate recall when witnessing a non-criminal event. We removed Instruction as a variable as this had no impact on recall accuracy. Additionally, as well as looking at overall accurate, inaccurate and confabulated event details we also looked at accurate, inaccurate and confabulated details for the sub-category of person detail. The reason for this was to obtain more detailed descriptions from our participants that may be crucial in a criminal investigation.

4.6 Experiment 3b: Introduction

In Experiment 3b, participants watching a video in which a crime occurred recalled more accurate detail than those watching a video in which no crime occurred. However, there was no difference in the number of accurate details recalled by change
detectors and non-detectors. These findings may have been due to the low level of
increasing the severity of the crime in their study, from a $5 theft to a $500 theft, led
observers to attend more to the perpetrator, resulting in a greater number of accurate
identifications. Furthermore, Stylianou (2003) found that people rate crimes against a
person as more severe than crimes against property. In terms of change blindness,
Nelson et al., (2010) tested the potential influence of ‘attention capture’ (see Simons,
2000), that is, if the crime captures attention, participants should be able to recall
accurate information about it and in turn, detect changes associated with the crime. In
their study, the change of perpetrators took place directly before the crime occurred.
Therefore, participants may have detected the change as they were focused on the
perpetrator as a result of the crime (Nelson et al., 2010). Based on this research, the
severity of the crime depicted in the event was increased for this experiment from a
theft to a mugging and we predicted again that the change detectors would recall more
accurate overall detail and more accurate people detail compared to non-detectors.

In Experiment 3a, to test observers’ change detection ability, two people in the
footage switched location during a cut in camera angle. However, as the two people
had featured in the footage for some time before the crime took place, observers
would have had enough time to encode them before the switch took place. The fact
that they had switched locations might not have become clear to observers as their
spatial awareness of the scene included two people sitting in two locations. To
minimise this effect in Experiment 3b, a change was recorded that introduced a
completely new person to the scene. Rensink (2002) argued that if a change introduces
something new to a scene (i.e. a person that has not featured in the footage
previously), observers might be better at detecting the change.
In terms of memory recall, previous research has found that participants’ recall of central event details tends to be better than their recall of peripheral/marginal event detail (see Christianson & Loftus, 1991). Similarly, Brown (2002) found that, for an arousal-provoking event, peripheral information was not remembered as well as central information.

In the current experiment the location of the change was manipulated and included one event that involved a change of perpetrator (central event) and one that involved a change of bystander witness (marginal event). We predicted that observers would recall more accurate event details and more accurate person details when the change was central to the event compared to when the change was marginal to the event.

4.7 Experiment 3b: Method

4.7.1 Participants

Seventy-six participants took part in the experiment (46 females, 30 males), ranging in age from 18 to 66 years ($M = 26.7$ years, $SD = 9.98$ years). The participants consisted of undergraduate students and staff at the University of Portsmouth. Psychology students and staff were not permitted to complete the study due to potential prior knowledge of change blindness and expectations of the nature of the study.

4.7.2 Design

Location of change (“Central change” or “Marginal change”) and Change detection (“Change detectors” vs. “Non-detectors”) were between-subjects independent variables. The dependent variables were the overall number of accurate, inaccurate and confabulated event details and the number of accurate, inaccurate and confabulated person details.
4.7.3 Materials

Mock CCTV footage was filmed using two JVC Everio digital cameras (model number GZMG750BEK), and the footage was edited using Adobe Premier Pro. Two black and white CCTV videos were created after the editing process. Each video was one minute and thirty seconds in duration and alternated every five seconds between two different camera viewpoints showing the interior and exterior of a university building. A crime (see Figure 4.3) took place in each video, involving a young man being attacked and his laptop stolen by two criminals outside the building.

![Figure 4.3: The two stills represent the crime that took place in each of the two videos. A male is seen leaving a University building, where two youths have been standing looking suspicious for the duration of the video. The male puts down his laptop bag to answer his mobile phone. As he reaches for his phone, one of the youths runs towards him and pushes him into the door whilst the other youth grabs the laptop bag. Both youths run off quickly, leaving the male victim dazed and shocked.](image)

The first video (central person change, see Figure 4.4) featured a change of offender during a switch in camera position. The second video (marginal person change, see Figure 4.5) featured a change of bystander witness during a switch in camera position.
Figure 4.4: Stills from the central person change video. One of the hooded youths, the perpetrator, changed identity during a switch in camera position.

Figure 4.5: Stills from the marginal person change video. The lady on the chair, a bystander witness, changed identity during a switch in camera position.

4.7.4 Procedure

Participants watched one of two videos involving either the central person change or the marginal person change. After the video, participants completed a questionnaire (see Appendix 2.1) measuring eyewitness memory recall from the footage and establishing whether or not they detected the change. Participants were asked the following questions; 1. Can you please describe what you observed in the video? 2. Can you please describe the people in the video in as much detail as possible? 3. Did you see anything change in the video? If so, please describe it below.
4.7.5 Coding Procedure

Coding for accurate, inaccurate and confabulated overall event details and classification of Change detectors and Non-detectors was the same in this experiment as for Experiment one. In addition, person details were also coded using the same principles as for event details. Person details were coded from Question 2 that asked participants specifically to describe the people they had seen in the footage.

4.8 Experiment 3b: Results

4.8.1 Location of Change

An ANOVA was conducted with Location of Change (“Central” or “Marginal”) as the independent variable and overall accurate, overall inaccurate and overall confabulated event detail as well as accurate, inaccurate and confabulated detail pertaining to people as the dependent variables. No significant univariate main effects for Location of change were obtained for any of the dependent variables (see Table 4.4).

4.8.2 Change Detection

Of the 76 participants tested, only 26 detected the change (34.2%). Of those, 69% detected the central change and 31% detected the marginal change. A one-way ANOVA was conducted with Change Detection (“Change detectors” or “Non-detectors”) as the independent variable and overall accurate, overall inaccurate and overall confabulated detail as well as accurate, inaccurate and confabulated detail pertaining to people as the dependent variables. The ANOVA revealed a significant effect of change detection on overall accurate event details, \(F(1, 75) = 4.20, p = .044, \text{ partial } \eta^2 = .054\), with change detectors recalling more accurate event detail overall, \((M = 34.27, SD = .16.12, 95\% \ CI [28.54, 41.51])\) than non-detectors \((M = 28.16, SD = 9.85, 95\% \ CI [25.42, 31.00]).\)
There was also a significant effect of change detection on accurate details about people, $F (1, 75) = 4.93, p = .029$, partial $\eta^2 = .062$, with change detectors recalling more accurate people details ($M = 28.69, SD = 13.89, 95\%$ CI [23.75, 34.79]) than non-detectors ($M = 22.90, SD = 8.80, 95\%$ CI [20.43, 25.53]). No significant univariate main effects for Change Detection were obtained for overall inaccurate details, inaccurate details about people, overall confabulated details or confabulated details about people (see Table 4.5).
Table 4.4  ANOVA results for each of the dependent variables for the Location of change conditions

<table>
<thead>
<tr>
<th></th>
<th>Central Change</th>
<th>Marginal Change</th>
<th>$F$</th>
<th>$p$</th>
<th>$\text{Partial } \eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accurate Details</td>
<td>31.08 (12.07)</td>
<td>28.18 (12.19)</td>
<td>.88</td>
<td>.352</td>
<td>.012</td>
</tr>
<tr>
<td>Inaccurate Details</td>
<td>2.50 (2.12)</td>
<td>2.11 (1.61)</td>
<td>1.68</td>
<td>.198</td>
<td>.221</td>
</tr>
<tr>
<td>Confabulated Details</td>
<td>.16 (.46)</td>
<td>.39 (.76)</td>
<td>3.44</td>
<td>.068</td>
<td>.044</td>
</tr>
<tr>
<td>Accurate People Details</td>
<td>25.75 (10.66)</td>
<td>23.11 (10.54)</td>
<td>1.09</td>
<td>.298</td>
<td>.044</td>
</tr>
<tr>
<td>Inaccurate People Details</td>
<td>1.97 (2.02)</td>
<td>1.50 (1.41)</td>
<td>.32</td>
<td>.573</td>
<td>.004</td>
</tr>
<tr>
<td>Confabulated People Details</td>
<td>.09 (.41)</td>
<td>.19 (.52)</td>
<td>.06</td>
<td>.802</td>
<td>.001</td>
</tr>
</tbody>
</table>

*p < .005
Table 4.5  ANOVA results for each of the dependent variables for the Change Detection conditions

<table>
<thead>
<tr>
<th></th>
<th>Change Detectors Mean (SD)</th>
<th>Non-Detectors Mean (SD)</th>
<th>F</th>
<th>p</th>
<th>Partial eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate Details</td>
<td>34.27 (16.12)</td>
<td>28.16 (9.85)</td>
<td>4.20</td>
<td>.044</td>
<td>.054</td>
</tr>
<tr>
<td>Inaccurate Details</td>
<td>2.50 (1.63)</td>
<td>2.18 (1.59)</td>
<td>.68</td>
<td>.411</td>
<td>.009</td>
</tr>
<tr>
<td>Confabulated Details</td>
<td>.12 (.33)</td>
<td>.38 (.73)</td>
<td>3.12</td>
<td>.082</td>
<td>.040</td>
</tr>
<tr>
<td>Accurate People Details</td>
<td>28.69 (13.89)</td>
<td>22.90 (8.80)</td>
<td>4.93</td>
<td>.029*</td>
<td>.002</td>
</tr>
<tr>
<td>Inaccurate People Details</td>
<td>1.73 (1.43)</td>
<td>1.60 (1.41)</td>
<td>.145</td>
<td>.704</td>
<td>.000</td>
</tr>
<tr>
<td>Confabulated People Details</td>
<td>.04 (.19)</td>
<td>.20 (.54)</td>
<td>2.21</td>
<td>.142</td>
<td>.029</td>
</tr>
</tbody>
</table>

*p < .005
4.9  **Experiment 3b: Discussion**

We predicted that observers would recall more accurate information overall and more accurate people detail when a change was central to the event compared to when the change was marginal to the event. However, accuracy was not affected by the location of change. This finding was unexpected as we anticipated that the crime would prompt greater attention (‘attention capture’, see Simons, 2000), thereby recall would be more accurate after attending to the central event of the footage (i.e. the theft of the laptop). One explanation for this finding may be the result of the post-experiment questions we asked and how we coded the data. In two separate questions, we asked participants to recall the crime that took place in the footage and to describe the people in as much detail as possible. Sarwar, Allwood and Innes-Ker (2014) tested their participants eyewitness memory for action information (what happened at the crime scene) and for descriptions of persons, objects, time and place. They found that their participants demonstrated more accurate recall for action information over any of the other categories. In future, research should integrate a more sophisticated coding scheme in terms of rating different types of information in free narrative accounts that specifically identifies information such as person, action information, location, item and temporal information (see PALIT coding scheme, Oxburgh, Ost & Cherryman, 2012).

In Experiment 3a there were no significant differences between overall accurate detail recalled between the change detectors and non-detectors. However, the findings of Experiment 3b supported the prediction that change detectors would recall more accurate event details than non-detectors. Furthermore, change detectors freely recalled significantly more person detail than non-detectors. The differing findings may be due to crime severity increasing in Experiment 3b and the fact that the crime
was against a person rather than a phone theft (Stylianou, 2003). This supports Nelson et al’s (2010) conclusion that increasing the severity of the crime may elicit more attention to the criminal during encoding, which in turn supports the attentional capture hypothesis (see Simons, 2000). However, this only applied to change detectors. Non-detectors were not as accurate in reporting overall and people details. An explanation for the difference may be as a result of where the participants visually attended to in the footage. The findings in Chapter 3 found evidence from an eye tracking study that change detectors, more so than non-detectors, fixated more often and for longer durations on the criminal. Therefore, change detectors in Experiment 3b may have recalled more overall accurate and accurate people details as they were fixating on the criminal for longer, resulting in greater encoding and more accurate detail being recalled compared to the non-detectors.

4.10 General Discussion

These two experiments were the first to apply a change detection paradigm in order to investigate how accurately observers can recall information from CCTV footage. Although Experiment 3a did not find any differences in the accurate event recall between change detectors and non-detectors, by increasing the severity of the crime, the context in which the crime was committed and the type of change, the change detectors in Experiment 3b recalled more accurate overall event and people details compared to non-detectors. Therefore, our findings support previous change detection research (e.g. Davies & Hine, 2007), by demonstrating that change detectors are more accurate at recalling accurate information compared to non-detectors.

The findings from Experiment one demonstrated that participants were more accurate in their recall of the Criminal compared to Non-criminal event. It is likely that the crime captured the observers’ attention, leading to more encoding and better
memory for the event (Laney & Loftus, 2010). Furthermore, the crime in Experiment 3a took place in a doctor’s waiting room which is not a common context for crime to take place. Therefore, there may have been little expectation about what crime would be committed, which in turn led to less attention being paid in order to encode details in the Non-criminal-event which supports the attentional capture hypothesis (Simons, 2000). In Experiment two, the behaviour of the perpetrators and the context of the crime may have been associated with stereotypical crime. That is, you would not expect a crime to be committed in a doctor’s waiting room (Experiment 3a context), however, it is more likely that crime would be committed by people loitering outside a building in a city centre (Experiment 3b context). This may have led to more accurate recall amongst change detectors compared to non-detectors.

In Experiment 3a, our instruction manipulation did not affect accurate memory recall. However the differences in our instructions were very small. Another way to test the role of prior information on CCTV observation in future research would be to provide detailed information to the participants before CCTV observation occurs. Karns and Rivardo (2010), gave a folder of information about a target person who participants had to track on CCTV footage. Laney and Loftus (2010) provided information about a suspect via media reports. This may have led to a greater reliance on top-down processing as detailed information was provided prior to observation of the footage.

Future research is required to understand the role of severity of crime on eyewitness recall accuracy. Not all criminal events featured in real-world CCTV footage are high in severity. We need a better understanding of how attention is allocated to different crimes. Also, we featured changes that were both central and marginal to the criminal event. There was no effect of location of change on accurate
recall and a large number of our participants failed to detect changes which were both central and marginal (although more changes were detected when the change was central). As it is common for multiple events to occur at the same time and in the same context on CCTV footage, it may be beneficial to test eyewitness accuracy for multiple simultaneous events.

4.1 Conclusion

In the current chapter, we applied a change detection paradigm in order to investigate, in two experiments, how accurately observers could recall information from CCTV footage. Change detectors recalled more accurate detail from the CCTV footage compared to the non-detectors, but only once the severity of the crime had increased. Findings supported the idea that there is more of a reliance on bottom-up processing (e.g Troscianko et al., 2011) compared to top down processing (e.g. Norris & Armstrong, 1999), as those watching a crime recalled more overall accurate detail than those watching an event with no criminal activity. However, there was no effect of instructions on accuracy, suggesting that top-down information may not have been as important in determining how much attention participants paid to the video. In terms of real-world CCTV observation and eyewitness accuracy recall, we have highlighted potential limitations regarding observers missing large perceptual changes in their visual environment and failing to recall important information. We have also demonstrated that vigilant observers who can identify changes in CCTV footage recall more accurate detail than those who experience change blindness. This research is important from a forensic perspective as it highlights limitations in memory recall and how observers attend to CCTV footage, both of which are relied upon as evidence in court.
4.2 References


Chapter 5: Experiment four: “Play it again Sam”: The effect of repeated viewing and the ‘think aloud’ protocol on change detection rates for a mock crime scenario on CCTV footage
5.1 Abstract

Closed circuit television (CCTV) is used for a variety of tasks including detecting criminal behaviour during real-time surveillance. However, very little is known about how people attend to and recall information from CCTV footage. In the current study, 50 participants were asked to verbalise about what they were seeing whilst they watched CCTV footage of a mock crime, and the other 50 participants watched the footage in silence. Furthermore, to test the role of attentional set, half of the participants were instructed to focus their attention on the people in the footage and half were given no specific instructions about where to look. During the CCTV footage, which depicted the theft of a laptop, there was a change in the identity of one of the criminals. If participants failed to detect this change during the first viewing, they were given the opportunity to view the footage again, up to four times. There was no effect of verbalisation or instructions on change detection or memory recall accuracy. The findings did however support the prediction that change detection would increase when participants were allowed repeated viewings of the footage.

5.2 Introduction

Closed-circuit television (CCTV) is used in the United Kingdom to monitor anything from real-time surveillance of street crime involving antisocial behaviour to capturing evidence post-event for criminal investigations and court cases (Keval & Sasse, 2006). Despite the advancement in CCTV technology and an increase in the use of cameras for security purposes, very little is known about the role of the human operator observing CCTV footage (Keval & Sasse, 2010). CCTV footage is displayed in a dynamic manner in that it is constantly switching between different camera angles often with numerous people and events competing for attention (Howard, Troscianko, Gilchrist, Behera & Hogg, 2009). Understanding how observers cope with this cognitively demanding task is critical because the constant switching between camera
angles provides ideal conditions for important information to be missed; effects referred to as inattentional and change blindness (Troscianko, Holmes, Stillman, Mirmehd, Wright & Wilson, 2004; Scott-Brown & Cronin, 2008).

Real-world demonstrations of inattentional blindness have shown that observers often fail to notice significant events in their immediate surroundings, for example failing to detect a fight breaking out next to the route they are running along (Chabris, Weinberger, Fontaine & Simons, 2011). Laboratory studies of change blindness have confirmed people’s inability to detect changes in their visual environment, for example a change in the identity of an actor that occurs between a cut in camera angle (Levin & Simons, 1997). Using CCTV footage as stimuli, researchers have recently shown that 65.2% of observers miss changes in the identity of a criminal (see Chapter 3). The aims of the present study were to examine whether change blindness rates during the complex task of CCTV surveillance could be decreased by instructing participants to verbalise what they are seeing, by allowing them to repeatedly view the footage, or by directing their attention to certain aspects of an event.

5.2.1 Verbalisation (the ‘Think Aloud’ protocol)

During real-time CCTV surveillance, CCTV operators often have to verbalise information from the footage to on-the-ground police officers or security personnel (Brown, 1995). This real-time monitoring of CCTV footage can avert further escalation of serious crimes (Welsh & Farrington, 2002). For example, CCTV footage taken from a police helicopter was instrumental when Nicholas Salvador attacked and killed Palmira Silva in Edmonton, North London in September 2014. Verbally communicating what was happening in the CCTV footage to police officers on-the-ground helped to ensure that members of the public were kept away from Salvador.
who was carrying a machete. Through the help of CCTV operators, Salvador was apprehend and prevented from hurting innocent bystanders (Evans, 2015). Operators thus had to make critical decisions, in real time, about what information from the CCTV footage was the most relevant and verbalise it clearly and effectively.

Verbalising has been used as a method in laboratory studies as a way of examining the cognitive processes involved while participants complete tasks. For example, Ericsson and Simon (1993) originally developed what they termed the ‘Think-Aloud protocol’ to understand potential differences in cognitive processes between groups of experts and novices. Thinking aloud has been integrated into research investigating reading strategies (see Cromley & Wills, 2014), decision-making (see Whitehead, 2015) and sport performance (see Ram & McCullagh, 2003). To date, very little research has integrated the think aloud technique into forensic research. One early study by Weaver and Carroll (1985), instructed both expert and novice shoplifters to “think aloud” whilst walking through shops about how they would intend to shoplift. Expert shoplifters provided more efficient and strategic descriptions related to the crime compared to novices. Weaver and Carroll (1985) concluded that the information gathered using think aloud could be used in a preventative nature to deter crime. On the other hand, verbalising has been found to increase cognitive load, leading to a decrease in performance (Van den Haak, Jong & Schellens, 2003).

In light of the research outlined above, it is suggested that the ‘Think Aloud’ technique may help participants detect the change in the footage as they are actively describing the people in the footage throughout the duration of the observation. We predicted that participants who verbalised during the observation of CCTV footage would detect the switching of two people between a cut in camera angle more often compared to those who did not verbalise.
However, the nature of increasing cognitive load due to the task might impact performance. This emphasises the importance of exploring verbalising during CCTV observation as operators often have to relay verbal information to police on the ground and security personal. Therefore, we wanted to explore whether those verbalising or non-verbalisers would go on to recall more accurate detail about the footage.

5.2.2 The Role of Instructions during CCTV Observation

CCTV is used in a variety of different ways (Keval & Sasse, 2006). Some examples include CCTV operators viewing real-time live CCTV footage, police officers searching back through footage post-crime or post-analysis to find evidence or members of the public observing segments of CCTV footage as part of a criminal appeal (Scott-Brown & Cronin, 2007). As a result of this, CCTV operators will have different motivations when undertaken those tasks. For example, Howard, Gilchrist, Troscianko, Behera, and Hogg, (2011) found that task-relevance determined where observers attended whilst watching CCTV footage, with participants fixating more often on suspicious behaviour only after being instructed to do so. However, Scott-Brown and Cronin (2008) highlighted that observers may over-focus their attention on irrelevant or misleading information if excessive or unnecessary information is provided to the observer. For example, participants in Simons and Chabris’s (1999) study missed a man in a gorilla suit walking across the screen because they had been instructed to focus on basketball players in white t-shirts. Prioritising where to look in a scene based on task-goals is referred to as attentional set (e.g. Most, Scholl, Clifford, & Simons, 2005). This in turn aids efficient visual search challenges that are faced day to day (Leber & Egeth, 2006). In Simons and Chabris’s (1999) study, participants were asked to count either the number of passes made by the basketball players in the white t-shirts or the number of passes made by the players in the black t-shirts. The
gorilla suit was black. Change detection was higher for those participants asked to focus on the passes made by the black t-shirt wearers than it was for those who were asked to focus on the passes made by the players in the white t-shirts. Simons and Chabris (1999) suggested that those focussing on the black t-shirts spotted the black gorilla suit because they were prioritising their attention to anything that was black in the scene.

In the current study, we examined how the role of specific instructions would affect the way observers attended to CCTV footage and in turn, impact upon their ability to detect changes. We predicted that those instructed to focus their attention on the people in the footage would detect the change in identity of one of the criminals more than often than those simply told to focus on the footage as a whole.

5.2.3 Repeated Viewing of Footage

Real-time CCTV surveillance is just one example of the uses of CCTV footage in criminal investigation. CCTV operators are also asked to conduct post-event analysis of CCTV footage after the crime has been committed in order to gather evidence and/or appeal to the public (Scott-Brown & Cronin, 2007). In such cases, the observer has the opportunity to watch the footage repeatedly. Whilst previous CCTV studies (see Chapter 2, 3 & 4) have found high change blindness rates, observers in those studies only had the opportunity to watch the footage once. Very little research has been conducted looking at the prevalence of change blindness across multiple viewings of CCTV footage. For example, to investigate this, Levin and Simons (1997) showed participants a video of two women having a conversation. During cuts in camera angles, different objects changed (e.g. one woman’s scarf disappeared). During the first viewing, only one out of ten participants noticed any of
the nine changes. After the second viewing and after being instructed to look for changes, participants noticed an average of two out of nine changes.

In some CCTV contexts, observers may have the opportunity of viewing footage repeatedly. We predicted that change detection would increase if observers had the opportunity to repeatedly view the footage compared to only viewing the footage once.

Therefore, the aims of the current study were to examine whether verbalisation, instructions and repeated viewing of footage effected change detection and memory recall during a CCTV observation task.

5.3 Method

5.3.1 Participants

One hundred participants took part in the experiment (54 females, 46 males), ranging from 18 years to 79 years of age (\(M = 28.7\) years, \(SD = 15.1\) years). The participants consisted of undergraduate students and staff at the University of Portsmouth. Psychology students and staff were not permitted to complete the study due to potential prior knowledge of change blindness and expectations of the nature of the study.

5.3.2 Design

Verbalisation (“Describe footage aloud” or “No verbalisation”), Instruction (“Focus your attention on the people” or “Focus your attention on the footage”) and Viewing times (Viewing one, viewing two, viewing three, viewing four) constituted between-subjects, independent variables. The dependent variables were the number of accurate, inaccurate and confabulated person, action, location, item and temporal details recalled (in writing) by the participants after they had watched the CCTV footage.
Change detection was recorded, for each condition, as the percentage of the participants who correctly detected the change. In subsequent analyses change detection was used as an outcome variable to ascertain whether or not people detected changes.

5.3.3 Materials

Mock CCTV footage was filmed using two JVC Everio digital cameras (model number GZMG750BEK), and the footage was edited using Adobe Premier Pro. The footage was one minute and thirty seconds in duration and alternated every five seconds between two different camera viewpoints showing the interior and exterior of a University building. A crime (see Figure 5.1) took place in the footage, involving a young man being attacked and his laptop stolen by two individuals. The footage featured one of the criminal’s switching with another person during a cut in camera angle (see Figure 5.2).

Figure 5.1: The two stills represent the crime that took place in the video. A male is seen leaving a University building, where two youths have been standing for the duration of the video. The male puts down his laptop bag to answer his mobile phone. As he reaches for his phone, one of the youths runs towards him and pushes him into the door whilst the other youth grabs the laptop bag. Both youths run off quickly, leaving the male victim dazed and shocked.
Figure 5.2: Stills from the video showing one of the hooded youths change identity during a switch in camera position.

5.3.4 Audio recordings

Participants in the verbalising condition were audio recorded using a Dictaphone (Model: Zoom H2n Handy recorder) as they observed the CCTV footage. Each recording was saved from the Dictaphone and given a unique number. The recordings were checked to ensure the participants were complying with instructions.

5.3.5 Procedure

Participants were randomly assigned to one of two verbalisation conditions ("Describe footage aloud" or "No verbalisation"). The instruction for participants verbalising was: "As you are watching the footage, I would like you to describe the footage aloud. I will be audio recording your voice, are you happy with that?" Those in the No verbalisation condition were given no instructions. Each participant was randomly assigned to one of two instruction conditions ("Focus your attention on the people" or "Focus your attention on the footage").

After viewing the footage for the first time, participants completed a questionnaire (see Appendix 2.1) measuring memory recall and establishing whether or not they had detected the change. Participants were asked the following questions; 1. Can you please briefly describe the crime that occurred in the video? 2. Can you
please describe the people in the video in as much detail as possible? 3. What do you believe you were focussing on the most in the video? 4. Did you see anything change in the video? If so, please describe it below and answer question 5. 5. How confident are you that you observed something change? Participants gave open ended responses (free narrative) to each of the questions. The length of their answers was not restrained in terms of space or length of time for completion of the questionnaire.

Once the questionnaire was completed, the response to Question 4 (Did you see anything change in the video? If so, please describe it below) was checked. If the participant failed to detect the change, they were given another opportunity to view the footage. They were given the following instruction: “You have missed something in the footage so I would like you to watch it again please”. The condition-dependent focus instruction and verbalisation instruction were repeated before the participants viewed the footage again. After the second viewing, participants were asked again if they had detected the change and to describe it (see Appendix 5.1). All participants were given up to four chances to detect the change. If they had not detected the change after the fourth time of viewing, participants were thanked for their time and they were debriefed.

5.3.6 Coding procedure

Participant responses to questions one and two (free narrative description of the event and people) were coded by an independent rater using the PALIT coding scheme adapted from Oxburgh, Ost and Cherryman (2010). Information was coded into the following categories: Person information; Action information; Location information; Item information; and Temporal information. The following examples detail the coding scheme: “The crime took place outside a building (2 x location details) on the 1st March 2006 (3 x temporal details). The male had dark hair and a
white football (3 x person details; 2 x item details). The woman was sitting down on the chair (1 x person detail; 1 x action detail). By referring back to the CCTV footage, each detail was further categorised as accurate or inaccurate.

A second rater independently coded 20% of the questionnaire responses. Interrater reliability was assessed using the percentage agreement method. For overall accurate details the raters agreed 95% of the time, for overall inaccurate details they agreed 95% of the time and for overall confabulated details they agreed 100% of the time. Where there were inconsistencies in total accurate, total inaccurate and total confabulations scores between the raters, the maximum difference was 5%. With these high percentage agreements, the first rater’s codes were used for the remainder of analyses.

The answers to question four were used post-hoc to classify participants as Change detectors or Non-detectors. If they accurately identified the change (i.e., change in identity of the criminal) they were labelled Change detectors, otherwise they were labelled Non-detectors.

5.4 Results

After viewing the CCTV footage for the first time, 59% of the participants detected the change. The 41% of participants who failed to detect the change during the first viewing were given the opportunity to view the footage up to four times. As shown in Table 5.1, change detection continued to increase during subsequent viewings. Only 4% of participants failed to detect the change by the end of the fourth viewing.
Table 5.1 Change Detection results across viewing condition

<table>
<thead>
<tr>
<th>Viewing Times</th>
<th>Change Detectors</th>
<th>Non-Detectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>One (n = 100)</td>
<td>59%</td>
<td>41%</td>
</tr>
<tr>
<td>Two (n = 41)</td>
<td>23%</td>
<td>18%</td>
</tr>
<tr>
<td>Three (n = 18)</td>
<td>9%</td>
<td>9%</td>
</tr>
<tr>
<td>Four (n = 9)</td>
<td>5%</td>
<td>4%</td>
</tr>
<tr>
<td>Overall</td>
<td>96%</td>
<td>4%</td>
</tr>
</tbody>
</table>

Chi-square tests showed no relationship between verbalisation and change detection, $X^2(1, N = 100) = 2.03, p = .155$, or between instruction and change detection, $X^2(1, N = 100) = 2.03, p = .155$.

A MANOVA was conducted with Verbalisation (“Describe footage aloud” or “No verbalisation”), Instruction (“Focus your attention on the people” or “Focus your attention on the footage”), and Change detection (“Change detectors” vs. “Non-detectors” as the independent variables. We classified change detectors as those participants who detected the change after the first viewing. The number of accurate and inaccurate person, action, location, item and temporal details were the dependent variables.

Participants who verbalised whilst observing the CCTV footage recalled a similar amount of accurate details in each category compared to non-verbalisers. Therefore, there was no significant multivariate main effect of Verbalisation, Wilks’ $\lambda = .833$, $F(10, 83) = 1.660, p = .104$, partial $\eta^2 = .167$, and no significant univariate main effects for Verbalisations (see Table 5.2).
The MANOVA revealed no significant multivariate main effect of Instruction, Wilks’ $\lambda = .902$, $F (10, 83) = .89$, $p = .098$ partial $\eta^2 = .098$ and no significant univariate main effects for Instruction (see Table 5.3) were obtained for any of the dependent variables. There was no significant difference in the amount of accurate detail recalled in all categories when participants were instructed to attend to the people in the video compared to instructing participants to focus on the footage as a whole.

Change detectors and non-detectors did not differ in the amount of accurate details they recalled as demonstrated in Table 5.4, with no significant multivariate main effect of Change Detection, Wilks’ $\lambda = .884$, $F (10, 83) = 1.088$, $p = .381$, partial $\eta^2 = .116$, and no significant univariate main effects for Change Detection.
Table 5.2 MANOVA results for each of the dependent variables for the Verbalising conditions

<table>
<thead>
<tr>
<th></th>
<th>Verbalisation Mean (SD)</th>
<th>No Verbalisation Mean (SD)</th>
<th>F</th>
<th>p</th>
<th>Partial eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person Accurate Details</td>
<td>22.76 (11.39)</td>
<td>20.48 (11.36)</td>
<td>1.97</td>
<td>.164</td>
<td>.021</td>
</tr>
<tr>
<td>Person Inaccurate Details</td>
<td>2.76 (2.60)</td>
<td>2.20 (2.01)</td>
<td>1.27</td>
<td>.262</td>
<td>.014</td>
</tr>
<tr>
<td>Action Accurate Details</td>
<td>10.64 (3.72)</td>
<td>9.74 (3.65)</td>
<td>2.42</td>
<td>.123</td>
<td>.026</td>
</tr>
<tr>
<td>Action Inaccurate Details</td>
<td>.38 (.70)</td>
<td>.30 (.61)</td>
<td>.62</td>
<td>.434</td>
<td>.007</td>
</tr>
<tr>
<td>Location Accurate Details</td>
<td>3.04 (1.67)</td>
<td>2.96 (1.85)</td>
<td>.15</td>
<td>.695</td>
<td>.002</td>
</tr>
<tr>
<td>Location Inaccurate Details</td>
<td>.00 (.00)</td>
<td>.12 (.39)</td>
<td>4.72</td>
<td>.123</td>
<td>.049</td>
</tr>
<tr>
<td>Item Accurate Details</td>
<td>3.30 (1.82)</td>
<td>2.86 (1.75)</td>
<td>4.52</td>
<td>.325</td>
<td>.047</td>
</tr>
<tr>
<td>Item Inaccurate Details</td>
<td>.26 (.63)</td>
<td>.32 (.65)</td>
<td>.01</td>
<td>.946</td>
<td>.000</td>
</tr>
<tr>
<td>Temporal Accurate Details</td>
<td>.52 (.97)</td>
<td>.56 (1.09)</td>
<td>.28</td>
<td>.601</td>
<td>.003</td>
</tr>
<tr>
<td>Temporal Inaccurate Details</td>
<td>.00 (.00)</td>
<td>.02 (.14)</td>
<td>.49</td>
<td>.488</td>
<td>.005</td>
</tr>
</tbody>
</table>
Table 5.3  MANOVA results for each of the dependent variables for the Instruction conditions

<table>
<thead>
<tr>
<th></th>
<th>Focus on People Instruction</th>
<th>Focus on Footage Instruction</th>
<th>$F$</th>
<th>$p$</th>
<th>Partial eta$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person Accurate Details</td>
<td>23.64 (11.04)</td>
<td>19.60 (11.46)</td>
<td>2.80</td>
<td>.098</td>
<td>.029</td>
</tr>
<tr>
<td>Person Inaccurate Details</td>
<td>2.44 (2.46)</td>
<td>2.52 (2.22)</td>
<td>.004</td>
<td>.949</td>
<td>.000</td>
</tr>
<tr>
<td>Action Accurate Details</td>
<td>10.56 (3.81)</td>
<td>9.82 (3.58)</td>
<td>1.62</td>
<td>.207</td>
<td>.017</td>
</tr>
<tr>
<td>Action Inaccurate Details</td>
<td>.36 (.69)</td>
<td>.32 (.62)</td>
<td>.34</td>
<td>.561</td>
<td>.004</td>
</tr>
<tr>
<td>Location Accurate Details</td>
<td>2.92 (1.72)</td>
<td>3.08 (1.79)</td>
<td>.19</td>
<td>.668</td>
<td>.002</td>
</tr>
<tr>
<td>Location Inaccurate Details</td>
<td>.06 (.24)</td>
<td>.06 (.31)</td>
<td>.28</td>
<td>.597</td>
<td>.003</td>
</tr>
<tr>
<td>Item Accurate Details</td>
<td>3.28 (1.95)</td>
<td>2.88 (1.61)</td>
<td>2.03</td>
<td>.157</td>
<td>.022</td>
</tr>
<tr>
<td>Item Inaccurate Details</td>
<td>.34 (.72)</td>
<td>.24 (.55)</td>
<td>.71</td>
<td>.402</td>
<td>.008</td>
</tr>
<tr>
<td>Temporal Accurate Details</td>
<td>.50 (.74)</td>
<td>.58 (1.26)</td>
<td>.16</td>
<td>.694</td>
<td>.002</td>
</tr>
<tr>
<td>Temporal Inaccurate Details</td>
<td>.02 (.14)</td>
<td>.00 (.00)</td>
<td>.49</td>
<td>.488</td>
<td>.005</td>
</tr>
</tbody>
</table>
Table 5.4  MANOVA results for each of the dependent variables for the Change Detection conditions

<table>
<thead>
<tr>
<th></th>
<th>Change Detectors Mean (SD)</th>
<th>Non-Detectors Mean (SD)</th>
<th>F</th>
<th>p</th>
<th>Partial eta²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Person Accurate Details</td>
<td>21.15 (11.08)</td>
<td>21.95 (11.66)</td>
<td>.02</td>
<td>.895</td>
<td>.000</td>
</tr>
<tr>
<td>Person Inaccurate Details</td>
<td>2.76 (2.65)</td>
<td>2.29 (2.08)</td>
<td>.68</td>
<td>.413</td>
<td>.007</td>
</tr>
<tr>
<td>Action Accurate Details</td>
<td>10.80 (3.33)</td>
<td>9.76 (3.90)</td>
<td>1.92</td>
<td>.169</td>
<td>.020</td>
</tr>
<tr>
<td>Action Inaccurate Details</td>
<td>.32 (.57)</td>
<td>.36 (.71)</td>
<td>.09</td>
<td>.803</td>
<td>.001</td>
</tr>
<tr>
<td>Location Accurate Details</td>
<td>3.10 (1.48)</td>
<td>2.93 (1.95)</td>
<td>.06</td>
<td>.771</td>
<td>.001</td>
</tr>
<tr>
<td>Location Inaccurate Details</td>
<td>.05 (.22)</td>
<td>.07 (.31)</td>
<td>.00</td>
<td>.987</td>
<td>.000</td>
</tr>
<tr>
<td>Item Accurate Details</td>
<td>3.29 (2.07)</td>
<td>2.93 (1.57)</td>
<td>.116</td>
<td>.285</td>
<td>.012</td>
</tr>
<tr>
<td>Item Inaccurate Details</td>
<td>.29 (.64)</td>
<td>.29 (.65)</td>
<td>.11</td>
<td>.738</td>
<td>.001</td>
</tr>
<tr>
<td>Temporal Accurate Details</td>
<td>.34 (.62)</td>
<td>.68 (1.22)</td>
<td>2.68</td>
<td>.105</td>
<td>.028</td>
</tr>
<tr>
<td>Temporal Inaccurate Details</td>
<td>.00 (.00)</td>
<td>.02 (.13)</td>
<td>.49</td>
<td>.488</td>
<td>.005</td>
</tr>
</tbody>
</table>
5.5 Discussion

The aims of the current study were to examine whether verbalisation, instructions and repeated viewing of footage effected change detection and eyewitness memory recall during a CCTV observation task. In contrast to much of the published research (e.g., Levin & Simons, 1997), a large number of participants detected the change during the first viewing of the CCTV footage (59%). There was no effect of instruction and verbalisation on change detection rates. Furthermore, there was no effect of instruction, verbalisation or change detection on memory recall accuracy. However, there was an increase in change detection rates after each viewing of the CCTV footage.

5.5.1 Verbalisation

As verbalisation is a technique that has been successfully used to inform us of the cognitive processes in different domains (e.g. decision making, Whitehead 2015), we wanted to explore if the technique aids change detection during CCTV surveillance. Thus the ‘Think Aloud’ technique was implemented in this study to attempt to model the tasks that take place in the CCTV control room where operators are required to relay information about footage in real time. We predicted that participants who verbalised during the observation of CCTV footage would detect the switching of two people between a cut in camera angle more often compared to those who did not verbalise. Our prediction was not supported, with no significant differences in change detection between those who verbalised and those who did not verbalise. Furthermore, we wanted to explore whether those verbalising would go on to recall more accurate detail about the footage compared to non-verbalisers after an increase in cognitive load. Both change detectors and non-detectors recalled an almost equal amount accurate detail. Verbalising whilst there are continuous cuts in camera angles, as well as the onset of different information, is a cognitively challenging task.
The increase in cognitive load due to the complexity of the task may have disrupted performance, as suggested in previous studies (Van den Haak et al., 2003).

One of the main aims of integrating the verbalisation condition was to see how that impacted performance during CCTV observation. For example, investigators were concerned that the noise of the busy control room effected the decision making of senior officers during the case involving the shooting and death of Jean Charles de Menezes in July 2005 (Cronin & Reicher, 2006). One crucial point is CCTV controllers may feel under increased pressure when carefully relaying information to another person. In contrast, our participants were in a low-pressure environment and were only speaking aloud to themselves. The stress of a real CCTV control room may not be fully reflected in our study and should be considered in future research. Future research could test participants all verbalising information in a noisy mock CCTV control room environment. As an extension to the current study, it would be interesting to compare the recordings of the verbalisations with the eyewitness recall accuracy details coded from the post-experiment questionnaires. This would establish whether the verbalised information was indeed accurate and whether there was consistency between verbalised detail and that recorded in the post-event written questionnaires.

5.5.2 Instructions

In the current study, we examined whether providing instructions on what to focus on in the footage would affect the way observers attended to CCTV footage. In turn, we wanted to investigate if instructions would aid change detection and accurate recall regarding details from the footage. The results showed the instructions did not aid change detection. Also, instructing participants to focus on the people or the footage led to a similar amount of accurate recall detail between the two groups.
Providing instructions before a task has been shown to effect attentional set (Most et al., 2005; Karns & Rivaro., 2010). We had two specific instructions in the study; “please focus on the people in the footage” or “please focus on the footage”. It may have been beneficial to have more specific or detailed instructions. For example, returning to Simons and Chabris (1999) gorilla study, participants were specifically told to focus on the basketball players in either the white or black t-shirts. This is a very specific instruction and it was clear how attentional set influenced the rate of change detection in the Simons and Chabris study. Similarly, Karns and Rivardo (2010) gave participants detailed information about the target person they were searching for in the CCTV footage. The information provided effected whether or not they noticed an unexpected event taking place in the footage. Therefore, it could be that our “focus on the people” instruction was too general and needed to be more specific. Future research using a similar CCTV task should give more specific information to the observer. For example, “please look for a man wearing a black cap”. This would allow an investigation into whether observers attend to information relevant to the task at hand (i.e. only attending to people wearing black caps and filtering out all other information).

5.5.3 Change Detection and Repeated Exposure

We predicted that change detection would increase if participants were given the opportunity to view the CCTV footage several times. This condition was included to reflect situations in which CCTV footage is watched repeatedly after a crime has taken place to gather evidence or appeal to the public (Scott-Brown & Cronin, 2007). The change detection rate increased after repeated exposure to the CCTV footage, with 96% detecting the change after up to four opportunities to observe the footage. This high rate of initial change detection contrasts markedly with the findings of
previous change blindness research (e.g. Levin & Simons, 1997). One reason for this may be that the mock CCTV footage was relatively uncluttered compared to some real-world CCTV. Therefore there was less aspects of the footage to attend overall. It may also be plausible that our participants were suspicious of the nature of the experiment prior to testing. We could ask participants post-testing if they had an intuition as to what the study was about.

These findings also highlight the importance of having the opportunity to inspect CCTV footage multiple times when searching for evidence. A crucial piece of information may be missed during the first or second viewing, but picked up on the third or fourth viewing. It is important to highlight though that even after viewing the footage four times, four participants still failed to detect the change overall.

Replicating this study with eye tracking technology may provide an insight into how both change detectors and non-detectors distribute their attention the first time they watch CCTV footage compared to when they watch it on subsequent occasions.

5.5.4 Change Detection and Memory Recall

In the present study, there was no difference in overall recall accuracy between change detectors and non-detectors. The accuracy was very high in terms of the number of details recalled. This finding does not support the prediction that change detectors would recall more overall accurate details compared to non-detectors. This does not support previous research (see Chapter 4) who found more overall accurate information from participants who detected the change compared to those who experienced change blindness. It is important to note that this high level of accurate details might explain the high numbers of change detectors. Such high rates of accurate detail suggest that participants in the current study carefully inspected the footage. In Woolnough and MacLeod’s (2001) field study, participants reported more
action details overall after witnessing a real crime. However, in our laboratory-based study, participants recalled more person details that any of the other categories (action, location, item and temporal). Ihlebaek, Love, Eilertsen and Magnussen (2003) tested participants’ memory for a staged robbery by having one group of participants watch the event live and the other half of participants watch the event on video. They found that those watching the crime on video recalled more details and with a higher accuracy than those participants who were at the scene of the crime. The reason for Ihlebaek et al’s (2003) findings, along with the results from Woolnough and MacLeod’s (2001) study may be that the amount of information observers have access to when witnessing an event negatively correlates with their recall of accurate details. In the real world, observers do not have the advantage, as in the current study, of having a clear view of the crime and multiple opportunities to remember information about the crime. Supporting evidence comes from research by Hope et al., (2015) who found that firearms officers who were directly involved in a critical incident were less accurate at recalling details about the incident than those who were simply observing the incident on a video. Future research should compare accurate recall for expert CCTV operators during the observation of criminal events with those observing footage from a lab to see if the nature of the task impacts accurate recall.

5.6 Conclusion

In the current study, we used a change detection paradigm to investigate whether verbalisation, instructing to focus on people in the footage, or repeated viewing of the footage would aid change detection and accurate memory recall. There was a higher number of change detectors after the first viewing compared to non-detectors. Furthermore, change detection increased after participants had the opportunity to view the footage up to four times. In real-world post-event analysis, observers have to search through CCTV (e.g., different views of the street in which a
crime took place) repeatedly to obtain evidence. The current findings are encouraging in that important visual information is detected during the process of repeated viewing. Verbalisation and instructions had no effect on change detection or the accuracy of eyewitness recall. There was a large number of overall accurate details reported, with person details dominating, however, there were no differences in eyewitness recall between change detectors and non-detectors. Future research should attempt to replicate the control room environment to further understand how observers attend to CCTV footage and make decisions when they are under pressure. This research is important from a forensic perspective as it highlights both the limitations in memory recall and how observers attend to CCTV footage, both of which are often relied upon as evidence in court.

5.7 References


Chapter 6: General Discussion
6.1 General Discussion Outline

In this chapter I will firstly summarise the main findings of the thesis. Second, the theoretical implications will be discussed, focussing on the impact of event characteristics and instructions on fixation behaviour, as well as memory recall (see Section 6.3). Third, the practical implications of my findings will be outlined specifically the implications for CCTV surveillance and the training of operators (see Section 6.4). Fourth, the methodological issues stemming from this thesis will be highlighted including the limitations of eye tracking research, change blindness as a test of attentional and perceptual limitations, the think aloud protocol, and repeated viewing of CCTV footage (see Section 6.5). Fifth, limitations of the research will be discussed (see Section 6.6). Finally, whilst ideas for further research are suggested throughout this chapter, an overview of ideas for future lines of enquiry are summarised in Section 6.7.

6.2 Overview of Main Findings

Although CCTV footage is used for both crime prevention and police investigations, relatively little is known about the strategies that observers use when monitoring and interpreting (criminal) events observed in such footage. Four studies reported in this thesis used a change blindness task to explore: (a) whether instructions and/or event type influence where people attend during CCTV observation; (b) how factors such as task instructions and central and marginal information influence fixation behaviour during CCTV observation; (c) the effect of change detection on memory recall during CCTV observation; and (d) whether verbalisation, attentional set and/or repeated viewing improved change detection and memory recall rates for CCTV footage.

Experiment 1 examined whether instructions given prior to observing CCTV footage (“detect a crime”, “detect anything unusual” or simply “watch”) or event type
(criminal or non-criminal) influenced participants’ fixation behaviour. Furthermore, a change detection paradigm was included, involving a switch in location of two actors. Overall, there was no effect of instructions on fixation behaviour, which was contrary to a large body of literature stating that task instructions influence fixation behaviour (Mills, Hollingworth, Van der Stigchel, Hoffman & Dodd, 2011). However, the majority of that research has been conducted using static scenes viewing (e.g. Henderson, Weeks, & Hollingworth, 1999; Castelhano, Mack, & Henderson, 2009), compared to dynamic displays (e.g. Howard et al., 2011). That said, there is far more literature demonstrating the role of instructions on fixation behaviour during static scene compared to dynamic scenes. Participants in Experiment 1 who observed a criminal event fixated for longer on the target (i.e. the perpetrator) as the crime took place compared to those watching the no-crime video. The large number of fixations on the target during the crime could be the result of an increase in the complexity of the footage and the need to try to understand the unfolding criminal event, compared to the less complex ‘no-crime’ event (Birmingham, Bishof & Kingstone, 2008). Therefore, Experiment 1 is the first study in the literature to show that the event in the CCTV footage guided fixation behaviour, but only when the event was criminal in nature. Consistent with previous change blindness studies (e.g., Levin & Simons, 1997), only 24% of the participants detected the change in identity of a target male. Change detectors made fewer fixations but of significantly longer duration on the target just prior to the change than non-detectors. Fixation behaviour directly before the change took place was therefore a predictor of change detection. That said, fixation behaviour during the change did not differ significantly between detectors and non-detectors.

Experiment 2 extended Experiment 1 by providing more specific instructions to participants (‘focus on people’ or ‘focus on objects’) in an attempt to increase
change detection. It was predicted that instructing participants to focus on the people might improve change detection rates. We also included central and marginal changes in the footage to investigate whether participants fixated more on central information compared to marginal information. Finally, we wanted to further explore the finding from Experiment 1 that the fixation behaviour of change detectors may act as a predictor of change detection. We replicated the finding from Experiment 1, that instructions to focus on ‘objects’ or ‘persons’ did not influence fixation behaviour. Moreover, it made no difference to change detection rates whether participants were instructed to focus on people or objects. However we did find, in Experiment 2, that participants fixated more and for longer on central details in the footage compared to marginal details. This finding supports previous research demonstrating that observers fixate towards central information over marginal information in both static and dynamic displays (Christianson, Loftus, Hoffman, & Loftus, 1991; Underwood, Chapman, Berger, & Crundall 2003 respectively). Furthermore, change location influenced change detection, with more participants detecting a central change compared to a marginal change. Overall the number of change detectors was higher in this experiment (34.2%) than in Experiment 1 (24%). Fixation behaviour was once again a predictor of change detection, with change detectors producing more and longer fixations on the targets directly before and during the change compared to non-detectors. Therefore, not only did we replicate the finding from Experiment 1, with the change detectors fixating on the changing target directly before the change, change detectors in the current study also produced significantly more and longer fixations on the change target during the change compared to non-detectors. We increased the severity of crime from Experiment 1 to Experiment 2 (a mobile phone theft to a male being attack and mugged). This may explain the difference in fixation behaviour, with fixation behaviour differing significantly between our change detectors and non-
detectors in Experiment 2 during the change but not in Experiment 1. Importantly the results demonstrate clear fixation behaviour differences between change detectors and non-detectors, contributing to an understanding of how both groups attend to dynamic scenes.

Experiments 1 and 2 demonstrated that there were significant differences in fixation behaviour between change detectors and non-detectors during the observation of CCTV footage. Therefore, in Experiment 3, we investigated whether there were other differences between the two groups that may inform us further about the cognitive strategies change detectors adopt during CCTV observation. We applied a change detection paradigm in order to investigate for the first time in the literature, in two experiments, how accurately observers could recall information from CCTV footage.

We found that change detectors recalled more accurate detail from the CCTV footage compared to the non-detectors, but only once the severity of the crime had increased. That is, we found no difference in recall accuracy between detectors and non-detectors when the crime was the theft of a mobile phone but differences in recall accuracy emerged when the crime was a mugging. Findings also supported the idea that there was more reliance on bottom-up processing (e.g., Troscianko et al., 2004) compared to top down processing (e.g., Norris & Armstrong, 1999), as participants from Experiment 1 who observed the crime video recalled more overall accurate detail than those who watched an event with no criminal activity. Therefore, more attention was given to the criminal event taken place on the footage, resulting in more information being recalled about that event. As with Experiments 1 and 2, there was no effect of instructions on accuracy, suggesting that top-down information may not have been as important in determining how much attention participants paid to the
videos. In terms of real-world CCTV observation and eyewitness accuracy recall, we have highlighted potential limitations in terms of observers missing large perceptual changes in their visual environment and failing to recall important information.

In Experiments 1 and 2, we identified differences in fixation behaviour between change detectors and non-detectors, with change detectors fixating more and for longer on key targets in CCTV footage. Experiment 3 demonstrated that the group of change detectors from Experiment 2 recalled more accurate detail from the CCTV footage compared to non-detectors. That said, the levels of change detection in Experiments 1 and 2 were relatively low. Experiment 4 aimed to improve the rate of change detection during CCTV observation. It also aimed to replicate the finding from Experiment 3b, that change detectors would recall more accurate detail from the footage than non-detectors. For the final experiment, half of the participants were asked to verbalise what they were observing as they watched CCTV footage of a mock crime, whilst the other half of participants simply watched the footage in silence. Furthermore, to test the role of attentional set (see Most et al., 2005), half of the participants were instructed to focus their attention on the people in the footage and half were given no specific instructions about where to look. At some point in the CCTV footage, there was a change in the identity of one of the criminals. If participants failed to detect this change during the first viewing, they were given the opportunity to view the footage again, up to four times.

There was no effect of verbalisation or instructions on change detection or eyewitness recall accuracy. In fact, after the first viewing, 59% of participants detected the change. This was the highest level of change detection recorded for this programme of research and was no longer consistent with previous change blindness studies (e.g., Levin & Simons, 1997). After giving the participants the opportunity to
watch the footage up to four times, 96% of our participants detected the change. Therefore, findings support the prediction that change detection would increase when participants were allowed repeated viewings of the footage. This finding is positive in terms of post-event CCTV surveillance, where CCTV footage is often searched repeatedly for evidence. In many real life situations, however, repeated viewing is not possible.

To summarise, fixation behaviour demonstrated that observers were drawn to criminal events that are central to the footage, with change detectors fixating on perpetrators more often and for longer than non-detectors. The group of change detectors from Experiment 2 also recalled more accurate detail from the footage, possibly indicating a more thorough search of the scene. Change detection was improved dramatically in Experiment 4 when participants were able to repeatedly view the footage. That said, instructions and verbalisation made no difference in terms of change detection.

6.3 Theoretical Implications

The main theoretical implications of the findings obtained in this thesis are in the areas of fixation behaviour, the role of instructions, and memory recall.

6.3.1 Fixation Behaviour

The role of cognitive influences on fixation and scanning behaviour has been of interest since Yarbus’s classic experiments in 1967 (Tatler et al., 2010). As stressed for Experiments 1 and 2, it is difficult to establish a clear theory or model of fixation behaviour during scene perception (compared to reading, e.g., Reichle, Rayner & Pollatsek, 2003) as the task and stimuli are varied. Furthermore, the majority of current models of this behaviour are based on studies of static scenes or picture viewing paradigms (Castelhano et al., 2009), meaning it is difficult to generalise these
models to the broader context of interpreting dynamic stimuli (Tatler, Hayhoe, Land, & Ballard, 2011). One of the main aims of the present thesis was to develop an understanding of fixation behaviour during the observation of dynamic stimuli. The findings from the two eye tracking studies (Chapters 2 & 3) demonstrated three key findings; (a) fixation behaviour was influenced by the level of criminality depicted in the footage, (b) observers fixated more on central information in a dynamic display compared to marginal information, and (c) fixation behaviour was a predictor of change detection. I will address each key finding and its theoretical implications in relation to the CCTV context.

6.3.1.1 Fixation Behaviour and Criminal Events.

There has been no research to date that has directly investigated fixation behaviour when observing criminal compared to non-criminal events. An original contribution to the literature from this thesis is that the nature of the unfolding event guides eye movement behaviour, but only when the event was of a criminal nature. Furthermore, increasing the severity of the unfolding crime (mobile phone theft in Experiment 1 to aggressive attack resulting in the mugging of a laptop in Experiment 2) led to more and longer fixations towards the perpetrator. These findings support research by Howard et al., (2011), who found participants fixated more often towards suspicious behaviour in CCTV footage. The large number of fixations on the target during the crime could be the result of an increase in the complexity of the footage and the need to try to understand the unfolding criminal event. Therefore, more fixations were necessary to process the visual information (Birmingham, Bishof & Kingstone, 2008). Furthermore, the need to understand the intentions of the perpetrator in the footage may dictate how we respond, understand and attend to people in scenes (Baldwin & Baird, 2001). Importantly, the research in this thesis has demonstrated that we are visually drawn to criminal events and, through the fixation
patterns identified, we attempt to take in as much information as possible. This was demonstrated by the number and length of fixations which were greater for a criminal, compared to a non-criminal, event. In a CCTV context, it is encouraging that observers’ attention is more likely to be drawn to criminal events and inspect them in detail. What is less clear is where observers decide to attend to when multiple criminal events occur in the same context (e.g. the London Riots, 2011), and this is something future research should examine. Furthermore, no study to date has eye-tracked observers to see if they focus their attention more towards the perpetrator or the victim whilst witnessing criminal events.

6.3.1.2 Fixation Behaviour and Central Events.

Research has identified that observers are more likely to fixate on information central to a scene in contrast to information marginal to a scene, particularly when the scene is emotive or hazardous (Christianson, 1991; Underwood, 2003). What is less clear is whether these findings are applicable to CCTV observation. Indeed, the findings presented for Experiment 2 support previous research, with the participants fixating more and for longer on central information (the offender) in the footage compared to marginal information (a bystander witness). Tatler (2007) presented evidence that observers have a central fixation bias in scene viewing, regardless of task goals or allocation of image features. Despite the fact that Tatler’s (2007) study used only static images, it may be that the same bias can be attributed to CCTV observation. Future research should investigate, using eye-tracking methodology, whether this central fixation bias is reflected during the observation of dynamic displays as it is in static scene viewing. This might explain why observers fixate on central aspects of the scene and not marginal aspects.

In this thesis, we classed the marginal event as a woman sitting on a chair speaking on her phone, who was essentially a bystander to the main crime.
Participants may have fixated more towards the marginal event if it had been another crime. Therefore, both central and marginal crimes should be presented in CCTV footage used in lab studies. This would allow for direct comparison between key central and marginal events. Another idea would be to have a crime that ‘moves’ between two camera locations, which might mirror how CCTV operators have to track behaviour across multiple locations.

6.3.1.3 Fixation Behaviour and Change Blindness.

Despite a substantial literature on change blindness (Levin & Simons, 1997; Simons & Levin, 1998; Davies & Hine, 2007), little is known about the underlying mechanisms involved in being a successful change detector. Experiments 1 and 2 present the first studies to date that have directly investigated the difference in fixation behaviour between change detectors and non-detectors during CCTV observation. We found in Experiment 2 that fixation behaviour was a predictor of change detection, with change detectors producing more and longer fixations on the targets directly before and during the change compared to non-detectors. Therefore, not only did we replicate the finding from Experiment 1, where the change detectors fixated on the changing target directly before the change, the change detectors in Experiment 2 also produced significantly more and longer fixations on the change target during the change compared to non-detectors. Barnhart and Goldinger (2014) demonstrated during a magic trick (a coin placed beneath a napkin which disappears, reappearing under a different napkin) that participants who detected the coin moving produced different eye movements during the critical event compared to those who missed it. Therefore the research in this thesis, along with Barnhart and Goldinger’s (2014) demonstrated that fixation behaviour differed depending on whether critical information was detected.
In terms of the fixation behaviour before the change, it is plausible that participants fixated ‘ahead’ on the target in an anticipatory fashion, which in turn led to successful change detection. It also supports previous research that has found that anticipatory eye movements may fall on people associated with a task goal (Pelz & Conosa., 2001; Savelsberg, Van der Kemp, Williams & Ward, 2007). Therefore, future research, even within different dynamic contexts (e.g., looking at an air traffic controller’s visual display or searching through airport luggage on a screen at airports) should examine fixation behaviour directly before the task. Furthermore, future change blindness studies should focus on where participants are attending to directly before the change occurs and if change detectors display a similar pattern of fixations to those demonstrated in this thesis.

The findings from this thesis, in conjunction with similar research, will start to build up a detailed model of fixation behaviour during dynamic scene viewing that is currently missing in the literature.

6.3.2 The Role of Instructions

Although the literature is dominated with research concluding that task instructions influence where observers attend in static scene or picture viewing (Castelhano at el., 2009), recent research has shown that a similar finding occurs during dynamic scene viewing (e.g. Howard et al., 2011). As we have less of an understanding regarding how people inspect dynamic visual scenes, Experiments 1 and 2 of this thesis investigated how specific instructions influence fixation behaviour during CCTV observation. In short, we found that instructions did not influence fixation behaviour for dynamic scene viewing. However, we concluded that our instructions might not have been detailed or specific enough (for example, for Experiment 2 we simply asked participants to ‘focus on people’ or to ‘focus on
objects’). When Karns and Rivardo (2010) tested the role of attentional set during CCTV observation, they found participants attended to specific target people after receiving a folder of detailed information about those target people. This may have led to a greater reliance on top-down processing as detailed information was provided prior to observation of the footage. Also, in real-world CCTV surveillance, operators can request information when tracking a suspect. However, Scott-Brown and Cronin (2008) highlighted that observers may hyper focus on irrelevant or misleading information if excessive or inaccurate information is provided to them prior to observation of a scene. For example, providing incorrect information about what a suspect is wearing may unnecessarily direct attention towards innocent individuals in CCTV footage. Future experimental research should manipulate the way in which instructions are provided to CCTV operators to see whether this has an impact on gaze behaviour. Furthermore, the level of detail included in instructions could be manipulated to see whether there is a minimum level of detail required in order to influence CCTV observation strategies.

6.3.3 Memory Recall

Experiments 3 and 4 were the first to apply a change detection paradigm in order to investigate how accurately observers can recall information from CCTV footage. Although Experiment 3a did not find any differences in accurate event recall between change detectors and non-detectors, by increasing the severity of the crime, the context in which the crime was committed, and the type of change, the change detectors in Experiment 3b recalled more accurate overall event and people details compared to non-detectors. Therefore, our findings supported previous change detection research (e.g., Davies & Hine, 2007), by demonstrating that change detectors were better at recalling accurate information compared to non-detectors.
However, in Experiment 4, there was little difference in overall recall accuracy between change detectors and non-detectors. It should be noted that accuracy was very high in terms of the number of details recalled for all participants. Such high rates of accurate recall suggested that participants in Experiment 4 carefully inspected the footage. In Woolnough and MacLeod’s (2001) field study, participants reported more action details overall after witnessing a real crime. However, in our laboratory-based study, participants recalled more person details than any other category of detail (action, location, item and temporal). More recently, research by Hope et al. (2015) found that firearms officers who were directly involved in a critical incident were less accurate at recalling details about the incident than those who were simply observing the incident on a video. Future research should compare accurate recall for expert CCTV operators during the observation of criminal events with those observing footage from a lab to see if stress and the nature of the task impacts upon recall accuracy.

6.4 Practical Implications

The most obvious practical implications for the findings obtained in this thesis are in the areas of CCTV surveillance and the training of CCTV operators, though this section will also outline other areas of application.

6.4.1 CCTV Surveillance and Training

6.4.1.1 CCTV Operators

The limited CCTV research that has been carried out over the last two decades has provided informative, influential findings that have demonstrated the complexity of CCTV surveillance (e.g., Howard et al., 2011; Stainer, Scott-Brown and Tatler, 2013). Norris and Armstrong (1999) put forward an important point regarding the use of CCTV, stating that it is not the machinery that selects events or objects to monitor
in anticipation of further action; it is the human operator. Despite this, investigating how observers attend to and interpret information from CCTV footage is a neglected area of research (Williams, 2007). The novel research in this thesis has implemented conditions that reflect real-world situations faced by expert CCTV operators in both live and post-event tasks. It has built on the limited existing CCTV literature by demonstrating that; (a) a large number of observers miss changes when observing CCTV footage, (b) we fixate more often and for longer on criminal events, (c) fixation behaviour informs us of the different visual strategies used by both change detectors and non-detectors during CCTV observation and (d) important information and changes can be detected after repeatedly viewing footage.

The research in this thesis, in conjunction with previous CCTV research, has the potential to inform training programmes for CCTV operators. This would predominantly inform operators about perceptual and attentional limitations inherent in CCTV surveillance.

Training programmes could be designed to inform operators of optimal search strategies. One training idea is based on the fixation behaviour data we obtained from the change detectors. Recent research has demonstrated that novices’ performance improved after they observed visual search behaviour via eye movements from experts in that field (e.g. Litchfield, Ball, Donovan, Manning & Crawford, 2010). Therefore, we could use the eye movement data from our change detectors to train CCTV operators. An important implication at this point is whether the change detectors identified in this thesis would perform to a similar level on subsequent change detection tasks.

Research has investigated the role of commentary training to improve performance during complex visual tasks. Isler et al., (2009) trained one group of learner drivers to create a commentary while watching a series of hazard perception
clips. When compared to an experienced group of drivers, the trained learners were found to detect fewer hazards before the commentary training took place, but were indistinguishable from the experienced group following commentary training. The trained learners out-performed the control groups after the training intervention. Similarly, Crundall, Andrews, van Loon and Chapman (2010) found that incorporating a verbal commentary of potential hazards during driving in a simulator resulted in fewer crashes and reduced speed on approach to hazards. However, Young, Chapman and Crundall (2014) found that the eye movement behaviour of drivers during a commentary indicated a more active interrogation of the visual scene. However, this can negatively impact performance in average drivers. Therefore, if we were to consider applying a commentary style training programme to aid CCTV operators as it had aided drivers to some extent, it would have to be extensively tested to ensure it is not detrimental to performance.

What classifies someone as an expert at detecting changes? There has been a recent focus in attention toward a group of people identified by the Metropolitan Police as ‘Super-recognisers’, who are able to remember a substantial amount of faces and use this skill in investigations (e.g. searching through CCTV footage, Potts, 2015). Further evidence by Davis, Lander, Evans and Neville (2012) showed that some police officers from the Metropolitan Police performed close to ceiling in terms of identifying unfamiliar and familiar faces during face-based tests. More recently, Bobak, Hancock and Bate (2016) found that those identified as ‘Super-recognisers’ were significantly more accurate at face matching and face memory tasks, including better recognition of faces from video footage. We propose that similar tests could be devised to identify ‘Super change-detectors’. This may supplement strategies for the police and other security organisations in terms of the recruitment of CCTV operators.
Another issue for consideration is that operators may be very confident in their ability and may believe that they would not miss important information when they are viewing CCTV footage. This same over-confidence has featured in change blindness research and is referred to as \textit{change blindness blindness}, which is the overestimation by participants of the degree to which they and other people would detect changes (Levin, Momen, Drivdahl & Simons, 2000). Therefore, we might find a similar overestimation amongst CCTV operators and this should be addressed in any research-based training programmes.

\textbf{6.4.1.2 Lay Observers}

It is no longer the case that it is just expert CCTV operators who observe CCTV footage. Critical incidents such as the James Bulger murder in which CCTV images, from the shopping centre where James was kidnapped and subsequently killed by Robert Thompson and Jon Venables in February 1993, were used to appeal to the public and have done much to accelerate both public and Governmental support for CCTV systems (Norris & McCahill, 2006). More recently, when Alice Gross went missing in Ealing, London in August 2014, police reviewed material from approximately 300 CCTV cameras (Agencies, 2014). They then appealed to the public for help in the investigation by showing CCTV footage and images of Alice and her potential attacker. In the UK, the BBC’s Crimewatch TV programme has an entire section dedicated to appealing to the public for help with criminal investigations using CCTV footage. An array of different CCTV clips are shown in quick succession, with a focus on the perpetrators. The research in this thesis has demonstrated that observers can miss important information but tend to be drawn to criminal events. However, it may be beneficial for the public to observe the footage more than once. Although all CCTV clips are available on the Crimewatch website, showing the clips twice during the programme may result in a larger likelihood of someone recognising something in
the footage. It is also crucial to ensure that the correct information from the footage is used to appeal to the public. The public has been instrumental in the conviction of perpetrators using CCTV footage. For example, Jakub Tomczak, who returned to Poland after brutally attacking and raping a woman in Exeter, was traced after CCTV footage was shown on BBC Crimewatch (BBC news, 2011). Therefore, it is not solely about how the public attend to CCTV footage, but the ways in which the visual information is displayed and used to appeal to them for help in criminal investigations.

6.4.2 Further Applications

The findings in this thesis are not constrained to CCTV surveillance. There are other cognitively demanding, visual-search tasks to which the findings from this thesis may also apply. One of the examples that appears throughout the thesis is driving behaviour (e.g., Underwood et al, 2003). Although our full visual field is not as constrained as a CCTV monitor, there are still limitations in terms of where we are able to look when we are driving. There are also a lot of factors competing for attention including avoiding other vehicles, attending to road signs, as well as avoiding any unexpected objects or people suddenly appearing.

The research in this thesis could also be applied to an airport context, in particular, to security personnel searching, via a monitor, through the contents of luggage. To date, relatively little research has focused directly on human performance during the task of aviation security screening (McCarley, Kramer, Wickens, Vidoni & Boot, 2004). This has become increasingly important with the ever-increasing potential threats arising from international/domestic terrorism (Scott-Brown & Cronin, 2008). Furthermore, searching through x-ray images on baggage screeners requires searching for multiple targets in the scene (e.g., guns, knives and explosives; Menneer, Barrett, Philips, Donnelly & Cave, 2006). Encouraging work from
McCarley et al. (2004) demonstrated that after practice, observers were faster at fixating on the target region of an x-ray image from a baggage scanner, and were both faster and more likely to recognise the target once they had fixated on or near it. Similar to the work in this thesis, more research is needed to identify ways to improve task performance for baggage scanners, with eye movement data being influential in that process. Focusing efforts into more research in this area may lead to more efficient detection of dangerous weapons or other contraband hidden in luggage.

6.5 Rationalising Methodologies

The following section will outline the rationale for my choice of the methodologies used in this thesis. I will discuss (i) eye tracking, (ii) change blindness as a test of attentional and perceptual limitations, (iii) the think aloud protocol and (iv) repeated viewing of CCTV footage.

6.5.1 Eye Tracking

Eye tracking is a technology that monitors eye movements as a means of detecting what and where an observer is looking when examining visual scenes. It is a popular method of gaining insight into attentional and cognitive processes (Papenmeier & Huff, 2010). The recording of eye movements during observation of natural scenes is often investigated using static images (Foulsham & Underwood, 2008; Henderson, 2003), but it is not always clear how well this research transfers to the real world and to dynamic displays. Howard, Troscianko, Gilchrist, Behera and Hogg (2009) stated that measuring eye movements during CCTV monitoring might produce innovative data to determine what strategies people use when attending to footage. Although the use of eye tracking technology has gained popularity, particularly in psychological studies, there are no standardised set of procedures to follow when designing a research study. What is of the utmost importance is that
researchers should use the measures that are most suited to answering their particular research questions. For example, when we read, we continually make eye movements called saccades. Therefore, ‘reading researchers’ tend to focus on saccades as a measure of gaze behaviour (Rayner, 1998). Between the saccades, our eyes remain relatively still during fixations, with fixations varying in terms of the amount and the duration of each. On the other hand, studies looking at scene perception or visual search tend to opt for fixations as measure, because these measures are sensitive to manipulations considered to influence cognitive processes underlying visual search performance (Zelinsky & Sheinberg, 1997; Rayner, 1998). Experiments 1 and 2 applied an eye tracking methodology to investigate fixation behaviour during CCTV observation. The rich fixation data obtained in Experiment 1 went on to inform the design of Experiments 2 and 4. Therefore, eye tracking is an important physiological tool that provides an insight into how our cognitive and perceptual systems can cope or, as demonstrated in this thesis miss, important visual information during cognitively challenging applied tasks.

6.5.2 Change Blindness as a Test of Attentional and Perceptual Limitations

It is important to investigate change blindness in CCTV monitoring as failures to detect change in applied forensic contexts (e.g., a switch between two people as a crime takes place leading to wrongful arrest) can have serious consequences. By necessity, a CCTV system must alternate between multiple views of a complex scene to try to capture as much information as possible. Therefore, the average CCTV system can be considered a ‘change blindness’ machine increasing the chance that a human operator may miss crucial information (Scott-Brown & Cronin, 2007). Little research, to date, has examined this possibility. Furthermore, there has been little research investigating the visual strategies of change detectors and non-detectors. By
implementing the change detection paradigm in all four studies, this thesis has contributed to developing an understanding of real-time visual strategies leading up to and during critical changes in CCTV footage. This may help to inform training courses aimed at instructing people how to optimally attend to CCTV footage. Furthermore, identifying specific visual strategies adopted by change detectors may help influence decisions on how we should attend to dynamic, constantly changing stimuli.

6.5.2.1 The ‘Think Aloud Protocol’

Experiment 4 utilised a verbalising or ‘Think aloud protocol’ to test how asking observers to verbalise what they were attending to effected their surveillance performance. There were three reasons for choosing this method. First, it is reflective of the task faced by real-world CCTV operators, whereby they often have to verbalise information from the footage to on-the-ground police officers or security personnel (Brown, 1995). This real-time monitoring of CCTV footage can avert further escalation of serious crimes (Welsh & Farrington, 2002). Second, verbalising has been used in laboratory studies, as a way of examining the cognitive processes involved while participants complete tasks (e.g., decision-making, Whitehead, 2015). Third, verbalising may improve change detection if observers describe the change as it happens in the footage simply because the verbalisation should draw attention to the change.

Contrary to the research findings and expectations outlined above, thinking aloud, as utilised in Experiment 4, did not increase change detection nor eyewitness recall accuracy. The literature states that CCTV monitoring places a heavy load on participant’s perceptual and cognitive systems (Howard et al., 2009). Therefore, the cognitive demands of verbalising during CCTV observation may have led to
difficulties for the participants. This finding would explain how verbalising in a real-
world CCTV control room might lead to serious consequences. For example,
investigators were concerned that the noise of the busy control room effected the
decision making of senior officers during the fatal shooting of Jean Charles de
Menezes in July 2005 (Cronin & Reicher, 2006). One crucial point is that CCTV
controllers may feel under increased pressure when carefully relaying information to
another person. These findings should be taking into consideration when considering
the stresses of control room on real-world CCTV performance.

6.5.3 Repeated Viewing

CCTV operators conduct post-event analysis of CCTV footage after the crime
has been committed in order to gather evidence and/or appeal to the public (Scott-
Brown & Cronin, 2007). In such cases, the observer has the opportunity to watch the
footage repeatedly. The participants in Experiment 4 were given the opportunity to
repeatedly watch CCTV footage featuring a change (a switch in the identity of the
perpetrator). Out of all the different variables presented in the thesis, allowing
participants to view the footage repeatedly was the one variable that dramatically
improved change detection. This elicited a high rate of initial change detection that
contrasts markedly with the findings of previous change blindness research (e.g.,
Levin & Simons, 1997). A study by Barnhart and Goldinger (2014) offers a plausible
explanation for our findings. They eye tracked participants observing a magic trick (a
coin placed beneath a napkin disappears, reappearing under a different napkin) to test
inattentional blindness (see Chapter 4 for a description of Inattentional Blindness).
The results showed that when participants watched several practice videos without
any moving coin, they became far more likely to detect the coin in the critical trial.
Barnhart and Goldinger concluded that allowing participants to repeatedly watch the
trial (albeit without the coin) reduced the perceptual load of the task (see Lavie & Tsal, 1994, for more detail on perceptual load theory) by freeing up attentional resources to detect the key to the trick during the critical trial. Therefore in Experiment 4, participants’ familiarity with the CCTV footage after repeated viewings may have freed up attentional resources (e.g., they knew where the people and the objects were in the scene and they knew what was going to happen) and this aided change detection.

Overall, these findings have highlighted the importance of having the opportunity to inspect CCTV footage multiple times when searching for evidence. A crucial piece of information may be missed during the first or second viewing, but picked up on the third or fourth viewing. What is unknown at this stage is whether participants change their viewing strategies after the first viewing once they are aware they missed something. Replicating this study with eye tracking technology may provide an insight into how observers distribute their attention the first time they watch CCTV footage compared to when they watch it on subsequent occasions.

### 6.6 Limitations

The sample used in each of the experiments in this thesis consisted of staff and students at the University of Portsmouth. No psychology staff or students were recruited for the experiments. Psychology students and staff were not permitted to complete the study due to potential prior knowledge of change blindness and expectations of the nature of the study. However, due to the popularity of change blindness experiments on-line and in popular media, there is a possibility the participants had some prior knowledge of this paradigm. Nevertheless, a substantial amount of participants in studies one to three failed to detect the change in the video footage used for these experiments.
The mock CCTV footage used in the studies was filmed at the University of Portsmouth. Filming the CCTV footage allowed for the change blindness element to be included. For example, we filmed several different actors committing a crime and edited the footage in a manner that allowed the identity of one actor to switch to another between a cut in camera angle. However, the mock CCTV footage was rather uncluttered, with a maximum of three or four actors in a scene at any given time. This is reflective of some real-world CCTV contexts, particularly in non-urban areas or away from busy main streets. However, there are a large number of CCTV cameras in busy environments such as the London underground and airports. Therefore, future research should consider using both busy and uncluttered CCTV footage to investigate how this variable impacts upon attention, and in turn, change detection.

In terms of data analysis, there are no standardised eye tracking measures to adhere to. This is due to the relatively new integration of eye tracking into psychological research and the variety of eye movement measures available. The eye movement measures selected for Studies 1 and 2 in this thesis were fixation count and fixation duration. Initially there were at least 6 potential eye movement measures selected for analysis. There is the potential to lose sight of the aims of a piece of research when consumed with a large array of eye movement data and a large number of different measures. Therefore, two measures were selected in the final analyses. Fixation count and duration were suited to the present studies (see page 4 of the General Introduction) and led to the novel and innovative findings which are presented in this thesis. Importantly, the flexibility of eye tracking data analysis software means that further analyses, using different variables, can take place in the future using the eye tracking data collected for this programme of research.
6.7 Ideas for Future Research

A range of ideas for future research has been highlighted in this chapter, with others suggested in the discussion sections of Chapters 2, 3, 4 and 5. The top nine ideas are summarised below. First, we suggest eye-tracking observers to see if they focus their attention more towards the criminal or the victim whilst witnessing criminal events. This could provide rich fixation data regarding where we attend during criminal events. Second, both central and marginal crimes should be presented in CCTV footage used in lab studies. This would allow for direct comparison between key central and marginal events. Third, future work should investigate, using eye tracking, whether a central fixation bias is reflected during the observation of dynamic displays as it is in static scene viewing. This might explain why observers fixate on central aspects of the scene and not marginal aspects. Fourth, future change blindness studies should focus on where participants are attending to directly before the change occurs and if change detectors display a similar pattern of fixations to those demonstrated in this thesis. Fifth, researchers should manipulate the way in which instructions are provided to CCTV operators to see whether this has an impact on gaze behaviour. Furthermore, the level of detail included in instructions could be manipulated to see whether there is a minimum level of detail required in order to influence CCTV observation strategies. Sixth, a direct comparison of recall accuracy should be made for expert CCTV operators observing criminal events compared to lay participants observing footage prepared for lab work (e.g., events filmed especially for research purposes). It would be interesting to see whether stress and the nature of the task impacts upon the accuracy of recall. Seventh, researchers could attempt, through multiple testing sessions, to identify individuals who are consistently good at detecting changes in CCTV footage. This may aid training and result in highlighting efficient search strategies. Eighth, future research should use eye tracking technology to record
the gaze behaviour of observers watching footage repeatedly to investigate where they
distribute their attention the first time they watch CCTV footage compared to when
they watch it on subsequent occasions. Finally, using the findings from this thesis and
in conjunction with similar research, future work should start to build up a detailed
model of fixation behaviour during dynamic scene viewing that is currently missing in
the literature.

6.8 Conclusion

Although CCTV footage is used in police investigations to prosecute
criminals, relatively little is known about the strategies that observers use when
monitoring and interpreting (criminal) events observed in such footage. This thesis has
demonstrated that there are differences in fixation behaviour between change detectors
and non-detectors, with change detectors fixating more and for longer on key targets
in CCTV footage. The same groups of change detectors from Experiment 2 recalled
more accurate detail from the CCTV footage compared to non-detectors. Furthermore,
change detection increased when participants were allowed repeated viewings of the
footage. This is positive in terms of post-event CCTV surveillance, where CCTV
footage is searched repeatedly for evidence. However, there are still limitations
involving live CCTV surveillance, where observers only see the footage once. The
findings from the thesis could be used to help train both expert CCTV operators and
the public about the perpetual and attentional limitations that are present as a result of
the cognitively challenging but highly important task of observing CCTV footage.

6.9 References

Agencies (2014, September 28). Alice Gross: RAF will join the search for missing
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will-join-the-search-for-missing-teenager.html


Appendix 2.1: Post-Experiment Questionnaire

Post-experiment Questionnaire

1. Can you please describe the crime in the video in as much detail as possible?

2. Can you please describe the people in the video in as much detail as possible?

3. What do you believe you were focussing on the most in the video?
4. Did you see anything change in the video? If so, please describe it below and answer question 5.

5. How confident are you that you observed something change? Please circle a number below.

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<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
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</thead>
</table>

Not at all confident                       Very confident
Appendix 5.1: Repeated Viewing Sheet

<table>
<thead>
<tr>
<th>Viewing Task</th>
<th>Participant No</th>
<th>________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viewing 2</td>
<td></td>
<td>________</td>
</tr>
<tr>
<td>1. Did you see anything change in the video? If so, please describe it below and answer question 2.</td>
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<td></td>
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<tr>
<td>2. How confident are you that you observed something change? Please circle a number below.</td>
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<tr>
<td>Not at all confident</td>
<td>Very confident</td>
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<tr>
<th>Viewing 3</th>
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<tr>
<td>1. Did you see anything change in the video? If so, please describe it below and answer question 2.</td>
<td></td>
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</tr>
<tr>
<td>2. How confident are you that you observed something change? Please circle a number below.</td>
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<tr>
<td>Not at all confident</td>
<td>Very confident</td>
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<tr>
<th>Viewing 4</th>
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<tbody>
<tr>
<td>1. Did you see anything change in the video? If so, please describe it below and answer question 2.</td>
<td></td>
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<tr>
<td>2. How confident are you that you observed something change? Please circle a number below.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not at all confident</td>
<td>Very confident</td>
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</tbody>
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Appendix A: Favourable Ethical Opinion (Chapters 2, 3 and 4)

Part C Information for Submissions to the Ethics Committee for Full Review

Title of proposed research: 

Name of researcher(s): 

This Ethics submission is for (please tick one of the following two options):

1) Full review for the first time
2) Expedited review (please tick one box)
   - A revision in response to Ethics Committee feedback. Please attach an additional sheet that details your responses to the concerns listed previously, along with the original submission.
   - Modification of already approved project – attach full previously approved proposal with a list of modifications or changes on a separate sheet
   - Departmentally funded summer bursaries (or equivalent)
   - Practicals (i.e. 1st or 2nd year undergraduate)
   - M.Sc. unit with short deadlines (N.B. This does not include the dissertation)

Checklist for expedited and full reviews: Check that each of the following documents is enclosed with this form:
(a) Written responses to the items 1-19.
(b) Recruitment information (e.g. letters to parents, information sheet, Participant Pool poster, if applicable).
(c) Informed Consent Form (required).
(d) Debriefing Form (required).
(e) All questionnaires / Interview schedule – (if applicable).

Decision of Ethics Committee: Date:

- Favourable opinion
- Favourable opinion with provision [make the changes indicated on the proposal – no need to resubmit]

- Unfavourable opinion - consult with your supervisor, tutor and/or mentor to rectify or address the concerns noted on the proposal, then resubmit following the instructions below:

- No opinion possible [see proposal for details]

N.B. Revised proposals should be submitted in the Coursework box, Floor 1 King Henry Building. Remember to tick the first box under 2 above, tick the front sheet (Expedited review) and include (i) the original submission, (ii) the revised proposal (including a new cover sheet), and (iii) a list of your responses to the feedback.
Appendix B: Favourable Ethical Opinion (Chapters 5)

Science Faculty Ethics Committee

Protocol Title: "Do you see what I see: investigating eyewitness memory during CCTV observation" SPEC 2014 - 090
Date received: 14/11/2014
Date Reviewed: 26/11/2014

FAVOURABLE OPINION WITH MINOR CONDITIONS

Dear Ms Graham,

Thank you for your submission for ethical review. Having completed their review, members of the Science Faculty Ethics Committee have reached a Favourable opinion, with minor conditions, of your proposal research. Please note that you are not required to resubmit your documents confirming that these conditions have been actioned.

Please make it clear in the debrief that this is not a real crime

Please notify the committee of any substantial amendments to the proposed procedures, send an annual report to the committee regarding study progress and a final study report once the study has concluded. Please send these to sci.fac@port.ac.uk.

Thank you for your submission and the Committee wishes you well with your study.

Dr Chris Markham – Chair of SPEC

CC -
Holly Shorter – Faculty Administrator

If you would like to offer any feedback on the Science Faculty Ethics Committee process please email sci.fac@port.ac.uk to be forwarded to the Chair.
Appendix C: UPR16 Form

**FORM UPR16**  
Research Ethics Review Checklist  
Please include this completed form as an appendix to your thesis (see the Postgraduate Research Student Handbook for more information)

<table>
<thead>
<tr>
<th>Postgraduate Research Student (PGRS) Information</th>
<th>Student ID: 476900</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGRS Name: Gemma Graham</td>
<td></td>
</tr>
<tr>
<td>Department: Psychology</td>
<td></td>
</tr>
<tr>
<td>First Supervisor: Dr Lucy Akehurst</td>
<td></td>
</tr>
<tr>
<td>Start Date: Oct 2010</td>
<td></td>
</tr>
<tr>
<td>Study Mode and Route:</td>
<td></td>
</tr>
<tr>
<td>Part-time □</td>
<td></td>
</tr>
<tr>
<td>Full-time ☑</td>
<td></td>
</tr>
<tr>
<td>MPhil □</td>
<td></td>
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<tr>
<td>PhD ☑</td>
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<tr>
<td>MD □</td>
<td></td>
</tr>
<tr>
<td>Professional Doctorate □</td>
<td></td>
</tr>
</tbody>
</table>

| Title of Thesis: The (Change) Blindingly Obvious: Investigating Fixation Behaviour and Eyewitness Recall during CCTV Observation |
| Thesis Word Count: 38169 (excluding ancillary data) |

If you are unsure about any of the following, please contact the local representative on your Faculty Ethics Committee for advice. Please note that it is your responsibility to follow the University’s Ethics Policy and any relevant University, academic or professional guidelines in the conduct of your study.

Although the Ethics Committee may have given your study a favourable opinion, the final responsibility for the ethical conduct of this work lies with the researcher(s).

**UKRI Finished Research Checklist:**  
(If you would like to know more about the checklist, please see your Faculty or Departmental Ethics Committee rep or see the online version of the full checklist at: [http://www.ukri.org/what-we-do/code-of-practice-for-research/](http://www.ukri.org/what-we-do/code-of-practice-for-research/))

- a) Have all of your research and findings been reported accurately, honesty and within a reasonable time frame?  
   - YES ☑  
   - NO ☑

- b) Have all contributions to knowledge been acknowledged?  
   - YES ☑  
   - NO ☑

- c) Have you complied with all agreements relating to intellectual property, publication and authorship?  
   - YES ☑  
   - NO ☑

- d) Has your research data been retained in a secure and accessible form and will it remain so for the required duration?  
   - YES ☑  
   - NO ☑

- e) Does your research comply with all legal, ethical, and contractual requirements?  
   - YES ☑  
   - NO ☑

**Candidate Statement:**

I have considered the ethical dimensions of the above named research project, and have successfully obtained the necessary ethical approval(s)

Ethical review number(s) from Faculty Ethics Committee (or from NRES/SCREC): 2014-050

If you have not submitted your work for ethical review, and/or you have answered 'No' to one or more of questions a) to e), please explain below why this is so:


UPR16 – August 2016

Signed (PGRS): [Signature]  
Date: 27/01/2016