The effect of training on perception of crime scenes.

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ABSTRACT

Eyewitnesses are a vital part of the Criminal Justice System, thus their reliability is critical. The current research aimed to establish whether training can improve memory recall, and investigate the impact of time delay on memory for crime scenes. Fifty-six undergraduates were allocated to one of three training groups (untrained, attention trained, attention and memory trained) and then viewed three crime scene images whilst receiving relevant training instructions. A further ten crime scenes were viewed for five seconds each. A recognition memory test was administered either immediately ($n = 30$) or after seven days ($n = 26$). Eye fixations were recorded to assess the relationship between viewing behaviour and later recall. The findings highlighted the negative impact of time delay on recall ($p < 0.001$). Training affected accuracy, but not as predicted. The untrained group and the attention and memory trained group both scored significantly higher than the group trained in attention only ($p = 0.004$ and $p = 0.001$ respectively). Fixation count, but not duration, was linked to accuracy of recall ($p < 0.001$) but this did not differ across training group. It was concluded that training can influence eyewitness memory but more investigation is required.

KEY WORDS:	EYEWITNESS	ATTENTION	WEAPON FOCUS	MEMORY	EYE TRACKING

INTRODUCTION

Eyewitness evidence is regularly used in court and can often lead to the conviction of an offender. However, it does not always mean that the correct person has been convicted. Since the development of DNA evidence it has been found that innocent people have been wrongfully convicted (Cardozo, 2009; Howitt, 2002). The majority of wrong convictions are attributed to misidentification of eyewitnesses (Wells, Memon and Penrod, 2006). A report by the Innocence Project (Cardozo, 2009) states that eyewitness misidentification was the cause of wrongful conviction in 75% of 250 exonerated cases. Despite this, eyewitness testimonies are still heavily relied upon within the criminal justice system.

Due to the number of cases in which eyewitness identification has been found to be incorrect research has been carried out into the accuracy of eyewitnesses (Brewer and Weber, 2008; Memon, Hope and Bull, 2003; Sauer, Brewer and Wells, 2008; Steblay et al., 2001) and also research into the memory of eyewitnesses (Davies, 2007; Sharps, 2007; Whitehouse, 2008). However, little research has been conducted into the difference between trained witnesses, for example Police Officers, and lay people's accuracy as eyewitnesses (Christianson, Karlsson and Persson, 1998; Clifford, 1976; Clifford and Richards, 1977; Lindholm, Christianson and Karlsson, 1997).

Trained witnesses may be regarded as more reliable witnesses when giving evidence in court, by both jurors and judges. Police Officers, specifically, are regarded as better eyewitnesses (Lindholm, Christianson and Karlsson, 1997). Therefore the true accuracy of such eyewitnesses needs to be tested.

If trained witnesses are found to be more accurate when recalling details and events, why? Do they have certain viewing behaviour when at an incident? Do they focus more on particular points to ensure encoding of such details? Links have been found between eye movement and memory (e.g. Saint-Aubin, Tremblay and Jalbert, 2007). Does this differ between trained and non-trained witnesses? This research aims to progress towards answering these questions.

EXPERT vs. NON-EXPERT

Existing research investigating expertise (those with expert knowledge or skill) focuses mainly on chess players (Campitelli et al., 2007; Kiesel et al., 2009), scrabble players (Halpern and Wai, 2007; Tuffiash, Roring and Ericsson, 2007) and sporting performance such as basketball players (Memmert, 2006). However, the theories that have been proposed from such research are readily adaptable to an expert in any field, including eyewitnesses. One of the factors that can differentiate experts from novices is expert memory (Gobet, 1998).

It is suggested that visual perception is closely linked to expertise (André and Fernand, 2008). Existing knowledge is used to understand what it being perceived. As experience in a field is developed the knowledge base expands. This knowledge base is used to help organise memory (André and Fernand, 2008) and consequently aid recall: expert memory. Expert memory consists of schemas (Gobet and Simon, 2000) which 'allows material (elements of a scene, objects and verbal information) to be encoded very rapidly in LTM' (André and Fernand, 2008, pp.113).

This could be applied to eyewitness research in relation to certain individuals, for example Police Officers who are regularly exposed to crime scenes and have existing knowledge of criminal activity. Therefore, when witnessing a crime they can draw upon existing schemas and use their knowledge base to readily identify what is occurring. The Police Officer will then be able to encode the relevant details of the crime scene into their long term memory ready for future recall. Their perception of the crime scene is likely to be different to that of a civilian and subsequent recall more accurate.

The minimal, outdated, research investigating the difference between Police Officers and civilians as eyewitnesses is inconclusive (Ainsworth, 1981; Clifford and Richards, 1977). Research conducted by Lindholm, Christianson and Karlsson, (1997) has established that Police Officers are significantly more accurate than civilians at recalling details about the perpetrator and identifying the weapon used. The study consisted of 137 participants comprising of 56 university students, 39 police recruits in their first year and 42 Police Officers with 3 to 30 years experience. All participants viewed video footage of a robbery. Significantly, the students and Police recruits did not differ in accuracy of recall. Lindholm, Christianson and Karlsson, (1997) attributed the enhanced ability of the Police Officers to the existing knowledge and experience aiding encoding of relevant details. These findings are consistent with the concept of expert memory. Importantly, there was no difference between Police Officer and students/recruits in memory for the victim and other details of the crime scene. In addition, poor performance of offender identification was reported across all groups.

Comment [ISD1]: This is contradictory!

Similar findings were reported by Christianson, Karlsson and Persson, (1998). Police Officers' (n = 59) memory of a simulated crime was compared with recruits (n = 60), teachers (n = 31) and students (n = 61). Participants witnessed an assault with the use of a weapon through a series of slides. Again, Police Officers outperformed all other groups in recall of crime details.

Thomassin and Alain (1990) conducted research comparing police recruits with medical students and found no difference in accuracy. Despite this, the Police recruits did provide more details. They also made considerably more mistakes in offender identification whilst displaying greater confidence in their decisions. This is an important finding when considering the impact witness confidence has on jurors (Brewer and Burke, 2002).

A supplementary piece of research has been conducted by Zimmerman (under revision) comparing the accuracy of Police Officers and civilians as eyewitnesses but has yet to be published.

THEORY AND EXPLANATION

There are a number of possible theories that could provide an explanation as to why, and how, a trained eyewitness could make a more accurate witness. These include models of attention and memory, links between eye movements and memory, and confounding variables that affect the accuracy of eyewitnesses, such as weapon focus effect, stress and confidence. All of which are explored in further detail below.

ATTENTION and MEMORY

One of the main theoretical backgrounds in eyewitness research is memory. It is a vital part of eyewitness testimonies and research has been carried out to look at different variables that may affect memory. Attention is a critical part of memory for many models (e.g. Atkinson-Shiffron theory). Most infer that for something to be encoded to memory it first has to be attended to (Awh, Vogel and Oh, 2006).

The Atkinson-Shiffrin theory proposes three types of memory storage: sensory memory, working memory and long-term memory (Smith et al., 2003). When information in first attended to it is placed in the sensory store. It only remains for a matter of seconds. The information is then lost or placed in working memory. Working memory is for the information that has just been perceived (Kalat, 2007). A memory is stored in working memory for approximately 20 seconds (Smith et al., 2003). This information may then be transferred into long-term memory where it is retained for future retrieval. The level of processing at the encoding stage is influential in memory (Bentin, Moscovitch and Nirhod, 1998). A higher level of processing equates to greater recall or recognition (Lockhart and Craik, 1990).

Visual memory is a crucial element of eyewitness testimonies. For an eyewitness to recall the details of a crime scene what they observed must be encoded and preserved in long term memory to ensure accurate retrieval. Vision is a vital part of scene perception. What the eyes perceive and attend to determines what is encoded into memory (Berman and Colby, 2009).

During visual processing of a scene the eyes change location two to three times per second using saccadic eye movements (Gordon, Vollmer and Frankl, 2008). Saccades are separated by fixations whereby vision is stationery and information is encoded. The average duration of fixations during scene perception is 300ms (Hollingworth and Henderson, 2002). Visual processing requires foveal (direct line of vision) or extrafoveal attention (Saarinen, 1993). This occurs during fixations. Encoding is limited during saccadic eye movement (Matin, 1974; Ridder III and Tomlinson, 1997).

Eye Movement and Scene Memory

Eye tracking procedures have been used to assess eye movement during scene perception (e.g. Fehd and Seiffert, 2008; Rayner et al., 2009). Eye tracking involves the use of specific equipment and software that allows eye movements to be tracked, displayed and recorded onto computer equipment (Bartels, 2008). This data can be analysed to establish whether there is a relationship between fixation and subsequent encoding and retrieval of visual stimuli (Saint-Aubin, Tremblay and Jalbert, 200; Theeuwes, Belopolsky and Olivers, 2009).

Rayner et al. (2009) used eye tracking to assess the fixation duration required during scene perception to successfully complete visual search tasks and memory recall. It was established that scene perception requires at least 150ms of viewing, per fixation, to successfully encode the scene (Rayner et al., 2009). However, the gist of a scene can be recognized at a glance. It only takes 100ms or less for correct recognition of a scene (Greene and Oliva, 2009). This is significantly longer than required for reading, which requires only 50 to 60 ms (Rayner, Liversedge and White, 2006).

Scene memory does improve with increased durations of viewing (Melcher and Kowler, 2001). In a study assessing saccadic eye movements and visual scene memory Melcher and Kowler (2001) established that memory capacity is three to four objects for scenes viewed for one second and increases to five objects when the scene is viewed for 4 seconds. A relationship was established between the number of fixations and recall for longer durations. However, this was not the case for scenes viewed for a shorter duration. Recall existed for items not fixated on. These results are consistent with previous findings that indicate eye movement is not essential for presentation of less than 2 seconds (He and Kowler, 1992). It must be noted, however, that Melcher and Kowler's (2001) study consisted of only three participants and was conducted using computer generated images.

Nevertheless, similar findings were established by Underwood et al. (2008). 24 participants completed a comparison visual search task of 80 pairs of real world images. These consisted of indoor scenes such as a breakfast table or a washing machine. Findings indicated that 'attention is unnecessary for the partial recognition of an object' (Underwood et al., 2008, pp.159). Attention is, however, required for full identification.

The results from both these studies are consistent with the findings that indicate the gist of a scene can be accurately recognised at a glance (Greene and Oliva, 2009) but, longer is required to successfully encode a scene (Rayner et al., 2009). Essentially, it is apparent that, 'to effectively remember a scene, you need to attend to that scene' (Wolfe, Horowitz and Michod, 2007, pp. 962).

Studies have highlighted that memory for a scene is well above chance when objects within the scene have been attended to (Hollingworth and Henderson, 2002).

In three experiments conducted by Hollingworth and Henderson (2002) long term memory accuracy was over 80% in all conditions. Twelve undergraduate students participated in each of the three experiments. Each experiment involved viewing 36 computer generated natural scenes. Experiment one consisted of type changes, whereby the object is changed for an object from a different category, and token changes, whereby the object is replaced by an object from the same category. Experiment two incorporated a rotation change, whereby the same object is rotated, in replace of a type change. After a delay of between five minutes and 30 minutes participants completed a memory test for 12 of the scenes viewed, in experiment one and two. The results for experiment one were 93.1% accuracy for the type change condition and 80.6% for the token change condition. In experiment two, accuracy for the token change was again 80.6% and accuracy in the rotation condition was 81.9%. Experiment three involved forced choice, to assess change detection, and masking of the changed object after fixation. Accuracy levels in experiment three were 86.9% for the token change and 81.9% for rotation change. All three experiments provided strong support for long term retention of scene memory and indicate that recall is high. Other studies have supported these findings showing that scene memory is extremely high when objects have been attended to (Hollingworth, Williams and Henderson, 2001).

Significantly, visual attention can be directed and research has also established that memory of a scene can aid direction of attention (Chan, Hayward and Theeuwes, 2009; Hollingworth, 2006). Eye tracking studies have indicated that memory and knowledge of a scene can influence saccades and fixations (Motter and Holsapple, 2007). Becker and Rasmussen (2008) established that scene memory results in directed gaze patterns, subsequently equating to appropriate allocation of attention.

ACCURACY OF EYEWITNESS TESTIMONY

However, scene memory is not perfect. As stated, 100% of a scene is not encoded (Hollingworth and Henderson, 2002). This is an important factor when considering the use of eyewitnesses within the Criminal Justice System. Several factors have been found to affect the accuracy of an eyewitness testimony.

Lindsay et al. (2008) in researching the effect of viewing distance on accuracy found, from over 1,300 participants, considerable errors in judging the distance between themselves and the target. Despite this, there was no logical variation, on the accuracy of target description, over different distances. Target identification accuracy, however, did decline with distance.

Poor performance in encoding and subsequent identification of unfamiliar faces has been identified by Megreya and Burton (2008). There is also evidence of gender and race bias in face recognition. Accuracy in face identification improves when it involves someone of own race and/or own gender (Wright and Sladden, 2003).

Additional confounding variables include the time delay between witnessing an event and subsequent recall (Devilly et al., 2007; Ebbesen and Rienick, 1998), weapon focus (Cooper et al., 2002; Steblay, 1992; Wagstaff et al., 2003), confidence (Tenney et al. (2007) and stress (Pozzulo, Crescini and Panton, 2008; Valentine and Mesout, 2009). Each of these variables is explored in further detail below.

Immediate vs. Delay

Only a limited amount of information is stored in working memory and for a limited time only. For information to be retained over time it has to be encoded into long term memory (Smith et al., 2003). Therefore, if a witness is questioned about an event immediately after viewing it could be assumed that some of the details will be present in their working memory. However, if they were to be questioned after a delay only information that was encoded into long term memory would be retrievable. This is a critical area in eyewitness research considering the often lengthy delay between witnessing an event and testimony in court.

Devilly et al. (2007) questioned 61 participants about video footage immediately after viewing and then after a month's delay. There were 25 questions about the video consisting of 13 questions about central details of the scenes and 12 questions about peripheral details across the scene. The mean test scores for central (6.79 immediately and 5.84 delay) and peripheral (4.57 immediately and 2.85 delay) details evidenced significantly poorer recall after a delay. Similar results were reported by Ebbesen and Rienick (1998) who encountered fewer accurate details recalled after a 4 week delay when testing event memory.

On the contrary, Kvavilashvili et al. (2009) established that whether a person was questioned one to two days or 10 to 11 days after an event it did not affect the consistency of recall. Neither was there significant decay over time. Subjects were questioned again three and 4 years later and retention was good.

Weapon Focus

The accuracy of offender identification and other crime related information can be impaired as a consequence of a weapon being present during the crime. This is known as the 'weapon focus effect' whereby the witness's attention is focused on the weapon rather than on the offender, or other important details. Consequently, the eyewitness may not recall crucial details or incorrectly describe significant features (Davies, Smith and Blincoe, 2008; Kramer, Buckhout and Eugenio, 1990).

Two theories offer explanations as to the cause of the weapon focus effect (Pickel, 1998). Firstly, it is proposed that anxiety levels rise when a weapon is present in an incident and there are threats of violence. Consequently, attention is then focused on the weapon and other details are less likely to be remembered. However, many studies have found conflicting evidence to this theory (Kramer, Buckhout and Eugenio, 1990; Pickel, French and Betts, 2003). Pickel, Ross and Truelove (2006) conducted two studies with 230 and 113 undergraduate students. Both studies involved the participants witnessing an event portrayed by actors. Each study involved the use of threatening behavior and the perpetrator held either a gun (three different guns in study one) or a book. Anxiety levels were manipulated in study two to increase participants' anxiety. Pickel, Ross and Truelove (2006) concluded from both studies that a weapon does not automatically capture attention even in states of arousal. Secondly, the presence of a weapon in an unexpected environment causes attention to be focused on the unusual object. This theory has a vast amount of support (Henderson, Weeks and Hollingworth, 1999; Pickel, 1999).

A meta-analysis of 19 studies regarding the weapon focus effect (Steblay, 1992) concluded that the presence of a weapon affects eyewitness identification of offenders. Contrary to that, Wagstaff et al. (2003) conducted an archival analysis of real life crime witness statements and established that whether a weapon was present or not had no significant effect on eyewitness accuracy.

Crucially, the majority of research that supports the weapon focus effect is confined to the laboratory. The limited research that has been conducted using real crimes, involving actual victims or witnesses, indicates a trend in the opposite direction. Cooper et al. (2002) on interviewing 24 female prostitutes established that the amount of detail recalled significantly increased when there was a weapon present. The 24 women were interviewed about sexual assaults, 8 of whom reported the use of a weapon. For these women the mean number of recalled details was 55.69 compared to 38.44 for the 16 women who reported no weapon during the sexual assault. It must be noted, however, the accuracy of such recall was not assessed. Despite this, the results are still in contradiction to the weapon focus effect.

Confidence

The more confident a witness appears the more reliable they are perceived, but only a weak correlation has been found between accuracy and confidence (Brewer and Burke, 2002; Shaw III and McClure, 1996). Tenney et al. (2007), in research conducted with 103 undergraduate students, found that a confident witness was rated more credible 75.5% of the time over an unconfident witness. It is important to note that the method used for this research is, however, lacking in ecological validity. The ratings of reliability were based on written materials containing levels of confidence statements and not observations of a witness appearing before a court and jury.

Stress

Being an eyewitness to an offence may be extremely stressful for both lay people and Police Officers. Research has indicated that increased stress levels affect eyewitness accuracy. One study found that accuracy levels were significantly higher in low stress situations compared to high stress situations (Morgan III et al., 2004). A more recent study has obtained similar results finding that high anxiety levels are connected with more errors in identifications (Valentine and Mesout, 2009). Contrary to these findings are the results presented by Pozzulo, Crescini and Panton (2008) who established that although live viewing of a crime created higher levels of stress and arousal, compared to video viewing, this did not impact accuracy as an eyewitness. Stress and arousal did, nevertheless, impact eyewitness accuracy in the video viewing condition. These results highlight the potential implications of laboratory findings in eyewitness research.

However, in research that manipulated levels of stress (stressful or non-stressful) in role play situations for 120 Police recruits, stress did impact on recall (Yuille et al., 1994). The amount of details recalled reduced in the stress condition, but produced more accurate results. Recall of details in the stressful event was also preserved better over time. Conversely, research has shown that increased stress does not affect the general performance of Police Officers (Regehr et al., 2008). Consequently, it is important to note that trained witnesses, such as Police Officers, may react differently than lay persons in incidences with violence present; their anxiety levels may not increase as much, meaning they remain calmer in such situations.

The proposed differences between Police Officers and civilians may be a consequence of a combination of all these proposed models and explanations. It may be due to the use of different scanning strategies. Or, the fact that Police

Officers are trained to avoid the effect of weapon focus. The ability to remain calm in stressful situations may be a contributory factor in differences in eyewitness accuracy. Fundamentally, the question is whether there can be such a thing as an 'expert witness'. If Police Officers can be trained as eyewitness, using existing knowledge and experience to assist in allocation of attention and encoding of crime relevant details, can civilians be trained to be more accurate eyewitnesses?

HYPOTHESES

This research aimed to establish what effect training in focussing attention had on recall of events both immediately and after a delay. Also, is there a link between eye-movement and memory across time? The research aimed to answer the following questions: Does training in attention and memory have an impact on perception of crime scenes? If so, can a witness, therefore, be trained to be more reliable? Does the presence of a weapon influence memory?

In order to assess this there was three groups of participants. There was an untrained group, a group trained in attention and a group trained in attention and memory. All viewed a series of crime scenes, half with a weapon present and half without. Eye movements were recorded during this stage. Participants then undertook a memory test. Each group was divided, with half answering the questions immediately and half after a seven day delay.

It was hypothesised that:

1) The group trained in attention and memory would have a greater accuracy score on the memory test than the other two groups.
2) The participants who took the memory test immediately would have higher accuracy scores on the memory test than the participants who took the test after a seven day delay.
3) The presence of a weapon will have an effect on memory across all groups.
4) There would be a relationship between the number of eye fixations and accuracy on memory test.
5) There would be a relationship between the duration of gaze for areas viewed and accuracy on memory test.
6) The attention and memory trained group would exhibit differences in gaze patterns to the other two groups by directing their attention on crime related areas.

METHOD

DESIGN

A multi factor (3x2x2) mixed design was used. The first independent between-groups variable was type of training with three conditions: untrained (UT), trained in attention (AT) and trained in attention and memory (AMT). The second between groups factor was memory test, with two conditions: immediate test and delay test. The repeated measures factor was crime scenes with two conditions; weapon and no weapon. The dependent variables were (1) the accuracy score on the memory test; (2) percentage score on memory test for scenes with and without weapon (3) average number of eye fixations in areas of interest (AOI's) during scene inspection; (4) average gaze duration of AOI's viewed. The AOI's were defined in relation to the questions from the memory test.

PARTICIPANTS

An opportunity sample of 59 undergraduate psychology students was used. 56 participants undertook all stages of the research. Three participants, however, did not complete stage three (memory test) of the research. Therefore, their data was excluded from analysis. For five of the participants the eye tracking data was not sufficient, therefore, analysis was conducted on memory test scores only. The sample consisted of 49 females and 10 males, ages ranging from 19 years to 39 years with a mean age of 23 years. Participants were recruited from within lectures and seminars. A request for participants was also made via email correspondence (see appendix 3).

MATERIALS

Crime Scene Images

Thirteen images of crime scenes were used (see appendix 10). The images were obtained from the internet, from a variety of websites, by searching for 'crimes scenes' and 'crimes scenes with weapon' using Google. Each image is a close up of the offender committing a crime and, where present, the victim. Two of the images contain more than one offender. Two examples of these images are shown in figure 1.

Crime Scene 1 – No Weapon

Crime Scene 1 – With Weapon

Figure 1. Example crime scene images.

Three images were used for training purposes. Ten images were then used for the purpose of eye tracking and to test recall. Five of these images contained a weapon and five did not. The images were shown as a slide show with the three training images shown first. These were in the same order for all participants. The ten crime scenes were then placed in a random order to create ten versions of the slide show. Randomisation was conducted using Microsoft Excel. Appendix 6 highlights the random allocation of crime scenes to the ten slide show versions.

Eye Tracker

Tobii x50 eye tracking equipment was used to attain eye tracking data. A double screen configuration was used. The eye tracker is freestanding with a built in camera that can track vision within the range of approximately 20 x 15 x 20 cm (width x height x depth) at a distance of 60 cm from the screen (Tobii Technology, 2006). Binocular eye tracking is used whereby both eyes are tracked simultaneously (Tobii Technology, 2006). 'Eye tracking works by reflecting invisible infrared light onto an eye, recording the reflection pattern with a sensor system, and then calculating the exact point of gaze using a geometrical model' (Tobii Technology, 2008).

ClearView 2.7 software was used to view and analyse the data. A variety of data is provided including gaze patterns, gaze times and fixation counts. Areas of interest (AOIs) can be assigned to images. Gaze times in milliseconds and the number of fixations on the assigned AOIs are calculated.

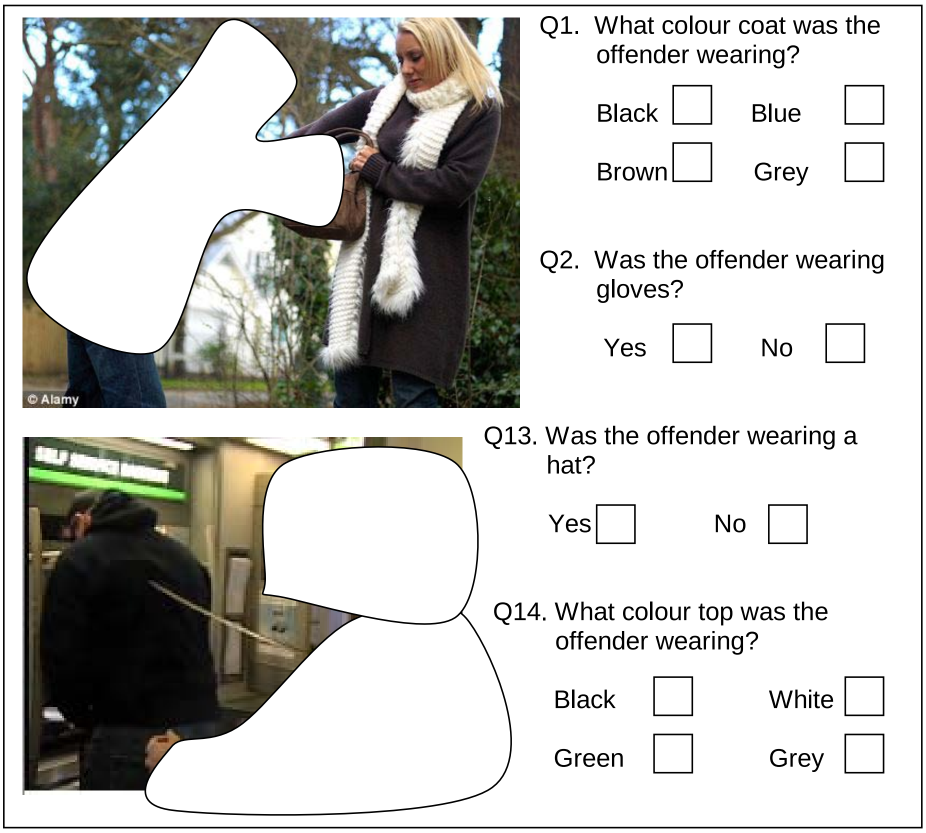

Figure 2. Example questions from the memory test.

Memory Test

A memory test was created including 20 questions relating to the ten crime scenes viewed. There were two questions per crime scene, all with a choice of four answers. The questions were crime related. They were questions that Police may use when interviewing a witness assess what was witnessed and to help identify offenders and victims. They included questions about the offenders and victims clothing, hair and gender and also what weapons were involved. Examples are shown in figure 2.

Participants were given a question sheet (see appendix 11) which contained the image along with the two questions. The areas of the scene that related to the questions was covered with a white block. Participants also received an answer sheet (see appendix 12) and was asked to place a tick in the corresponding box.

PROCEDURE

Participant Recruitment

Participants were given an information sheet (see appendix 4) informing them that the purpose of the research was to asses the effect of training on the perception of crime scenes. The three stages of the research were explained. Participants were advised that they had a minimum of 24 hours to think about whether they would like to take part. An email address was provided to request a time and date, suitable to both parties, for participation.

The information sheet advised participants that some of the images may be distressing, but that they would not be exposed to any physical harm, and advised against taking part if felt it would be distressing for them. Relevant contact details for support services were provided. Participants were all informed of their right to withdraw at any stage.

Participants were informed that all data would remain anonymous and presented as group data only. It would be stored securely, either locked away or password protected, and kept for a minimum of three years before being disposed of.

Consent Form

Participants were randomly allocated to one of the six groups (UT immediate or delay, AT immediate or delay and AMT immediate or delay). Randomisation of participant groups was conducted using Microsoft Excel (see appendix 7). This included the random allocation of which scene version would be used for each participant. Participants were asked if they wished to continue with the research and if so written consent was taken. All participants completed a consent form (see appendix 5) and gender and age was taken.

Calibration

Participants were seated in front of a computer screen and eye tracker. Prior to commencing the research a 5-point calibration of the eye tracker was required for each participant. They were informed that they would see a blue dot appearing on the screen at each corner and at the centre which they had to watch and follow. Once calibration was sufficient stage one of the research could commence.

Eye Tracking

Depending on their allocated group (UT, AT or AMT) participants were read the relevant instructions (see appendix 8). The untrained group were just asked to view images without specific instruction on what aspects to pay attention to and memorise.

The group trained in attention were told to pay attention to each of the images and asked to look for the Manchester United Football logo and shown an example of this (see appendix 9). This was something that did not actually appear in any of the images but could appear, for example on clothing, hat, scarf or background. The aim of this was to ensure that participants in the AT group were actually paying attention to each of the images.

Finally, participants in the attention and memory trained group were told to pay attention to each of the images. They were informed that they had to be prepared to memorise and recall relevant information as if witness to a crime scene. They were told to pay attention and memorise details about the victims and offenders, such as gender, hair, facial details, ethnicity, clothing etc. Also, to make note of any weapons or implements used. If vehicles were involved they were told to take note of the make, model, colour and registration number. They were advised to take note of the surroundings and be aware of anyone else present or witness at the scene.

All participants were informed that they would initially view three images of crime scenes (stage one), each presented for five seconds, as an example and practice of what would follow. After viewing the initial three training crime scenes participants were asked to inform the experimenter when they were ready to continue. Instructions for each group were again repeated and participants were informed that they would view a further ten crime scenes, each one for five seconds each, similar to those they had just seen.

Memory Test

Once the crime scenes had been viewed this completed stage two of the research. Then, dependent on what group the participant had been allocated to (immediate or delay) participants were either asked to answer the 20 questions straight away (immediate group) or asked to return after seven days (delay group) to complete stage three of the research. Upon their return after seven days they were asked to answer the 20 questions.

Debrief

After completing all three stages of the research all participants were thanked for their time and debriefed. They were reminded of their right to withdraw at anytime and informed of their participant number and experimenter contact details.

ANALYSIS

Accuracy

Accuracy was measured as a score out of 20 of the number of correct answers on the memory test. As the data is parametric a 3 (training group) x 2 (immediate vs. delay) analysis of variance (ANOVA) was used for analysis.

Weapon Focus

The weapon focus effect was calculated as a percentage of correct answers on the memory test, for the images with and without a weapon. In respect of the scenes without a weapon a percentage of correct answers out of ten were calculated. For the scenes where there was a weapon present the percentage of questions correct was calculated out of seven. This represented the number of questions that did not directly relate to the weapon. The data is again parametric so a mixed 3 (training group) x 2 (% correct or incorrect) x 2 (immediate vs. delay) ANOVA was used for analysis.

Eye Movement

To assess eye movement ClearView 2.7 software was used. Gaze plots were extracted directly from ClearView for each participant. Hot spot data was combined for participants for each of the three training groups and extracted directly from ClearView.

In order to establish how allocation of attention relates to recall, gaze time and fixation counts were used. To assess the gaze time and fixation data, firstly, AOIs had to be defined. These were created in relation to each of the questions from the memory test. So, for example, for crime scene one (no weapon) question one asked about the colour of the offenders coat. Therefore, the AOI was created to encompass the area covering the coat. Question two asked about the offenders gloves so, the AOI was created to cover the area surrounding the offenders hand.

Figure 3 highlights the AOIs for scene one (no weapon). Appendix 13 illustrates the AOIs for each of the ten test images.

Figure 3. Example AOIs for Crime Scene 1 – No Weapon

Then, to establish fixation count and gaze times in relation to these AOIs the data for each participant was exported into Microsoft Excel and entered into a pre defined AOI Tobii template. Once the fixation count and gaze time for each AOI for every participant was exported this then had to be prepared for analysis. The data was entered into an excel spreadsheet and each AOI matched to the relevant question. It was then indicated whether the question, on the memory test, was answered correctly or incorrectly for each participant.

To establish whether there is a link between the number of fixations at AOI and correct recall on the memory test the average number of fixations was calculated for all correct and incorrect answers. For gaze time the average time spent gazing within the AOIs was calculated for all the correct questions and incorrect questions. Any AOIs with a gaze time of 0.00 were excluded from these calculations. This was done to establish whether there is a link between the gaze time and correct recall for the AOIs that were viewed. As both sets of data are parametric a 3 (training group) x 2 (immediate vs delay) x 2 (correct or incorrect) ANOVA was used for analysis of gaze time and fixation count.

RESULTS

ACCURACY

Memory test scores for each participant, along with their gender, age and group allocation, were collated and entered into a table of raw data (see appendix 14). The mean reaction times, standard deviation and percentage correct for the six conditions are shown in table 1.

Table 1. Mean, Standard Deviation and % correct for accuracy scores (out of 20) for the 6 conditions.

Group	Test	Mean	Standard Deviation	% Correct	N
Untrained	Immediate	15.2	1.4	76%	10
	Delay	9.3	2.0	47%	8
	Total	12.6	3.5	63%	18
Attention Trained	Immediate	11.7	2.1	56%	10
	Delay	8.9	1.5	45%	9
	Total	10.4	2.3	52%	19
Attention and Memory Trained	Immediate	15.0	1.9	75%	10
	Delay	10.6	2.7	53%	9
	Total	12.9	3.2	65%	19
Total	Immediate	14.0	2.4	70%	30
	Delay	9.6	2.2	48%	26
	Total	11.9	3.2	60%	56

A 3 (training group) x 2 (immediate vs. delay) between-subjects analysis of variance (ANOVA) was used to analyse the data (see appendix 16). There was a significant main effect for training group [$F (2, 50) = 8.172$, $p = 0.001$] indicating that the level of training did effect accuracy scores on the memory test. Figure 4 highlights the mean memory test scores for each group.

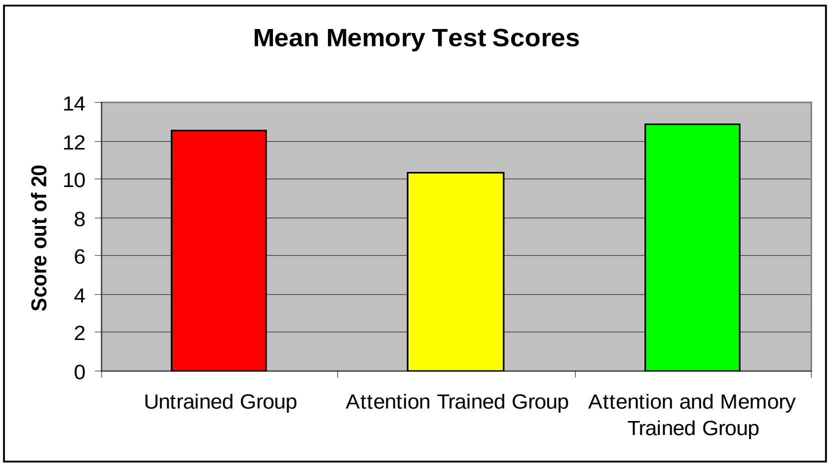

Figure 4. Mean memory test scores for the three training groups.

Tukey HSD post hoc analysis indicated that there is a significant difference ($p = 0.004$) between the mean test scores for the UT group ($M = 12.6$, $SD = 3.5$) and the AT group ($M = 10.4$, $SD = 2.3$), with participants in the UT group scoring higher in the memory test than those in the AT group. There was also a significant difference (p = 0.01) between the mean test scores for the AT group (M = 10.4, SD = 2.3) and the AMT group (M = 12.9, SD = 3.2), with participants in the AMT group performing better on the memory test. This was as predicted. However, there was no significant difference (p = 0.863) between the UT group (M = 12.6, SD = 3.5) and the AMT group (M = 12.9, SD = 3.2).

There was also a significant main effect for the test condition [F (1, 50) = 68.625, p = 0.000] highlighting an effect between taking the memory test immediately or after a seven day delay. The mean test score was higher when taken immediately (M = 14.0, SD = 2.4) than when taken after a delay (M = 9.6, SD = 2.2). These results are consistent with the hypothesis and are illustrated in figure 5. There was no significant interaction between the group and test conditions [F (2, 50) = 2.882, p = 0.065].

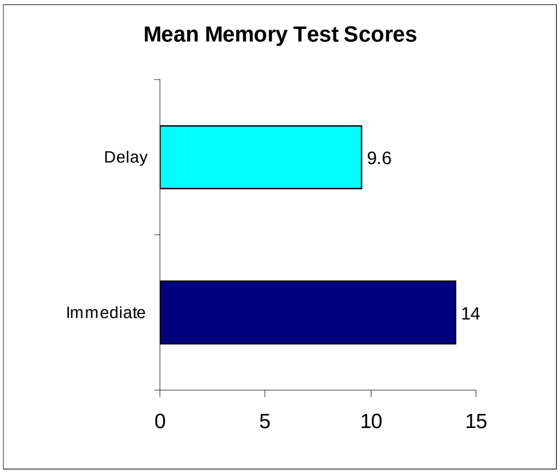

Figure 5. Mean memory test scores for immediate vs. delay

WEAPON FOCUS

The percentage score for correct answers on the memory test, for scenes with and without a weapon, were collated and are presented in the table of raw data in appendix 14. The mean percentage scores for each of the six conditions are presented in table 2.

A mixed 3 (training group) x 2 (immediate vs. delay) x 2 (presence of weapon) ANOVA was used for analysis (see appendix 17). There was no significant difference [F (1, 50) = 1.541, p = 0.220] between the percentage of correct scores for the scenes with a weapon present and the scenes with no weapon present. There was no significant difference between these scores across the training groups [F (2, 50) = 1.454, p = 0.243], or across the test condition [F (1, 50) = 0.492, p = 0.486]. Neither was there a significant interaction [F (2,50) = 1.505, p = 0.232].

Overall, accuracy scores were higher for the scenes where there was a weapon present (M = 60.68, SD = 21.705) than for the scenes where no weapon was present (M = 57.32, SD = 16.458). See figure 6. However, this difference was not significant. Therefore, the presence of a weapon did not affect accuracy and consequently, the null hypothesis has to be accepted.

Table 2. Mean and Standard Deviation for percentage accuracy scores, for scenes with and without a weapon, for the 6 conditions.

		% Correct for scenes no weapon		**% Correct for scenes with weapon**		
Group	**Test**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**N**
Untrained	Immediate	72.0	9.2	78.5	15.6	10
	Delay	42.5	10.3	48.3	16.5	8
	Total	58.9	17.8	65.1	23.5	18
Attention Trained	Immediate	55.0	12.7	60.0	20.9	10
	Delay	47.8	12.0	36.7	10.4	9
	Total	51.6	12.6	49.0	20.3	19
Attention and Memory Trained	Immediate	73.0	10.6	77.0	12.3	10
	Delay	48.9	15.4	58.6	16.3	9
	Total	61.6	17.7	68.3	16.8	19
Total	Immediate	66.7	13.5	71.8	18.2	30
	Delay	46.5	12.6	47.8	18.2	26
	Total	57.3	16.5	60.7	21.7	56

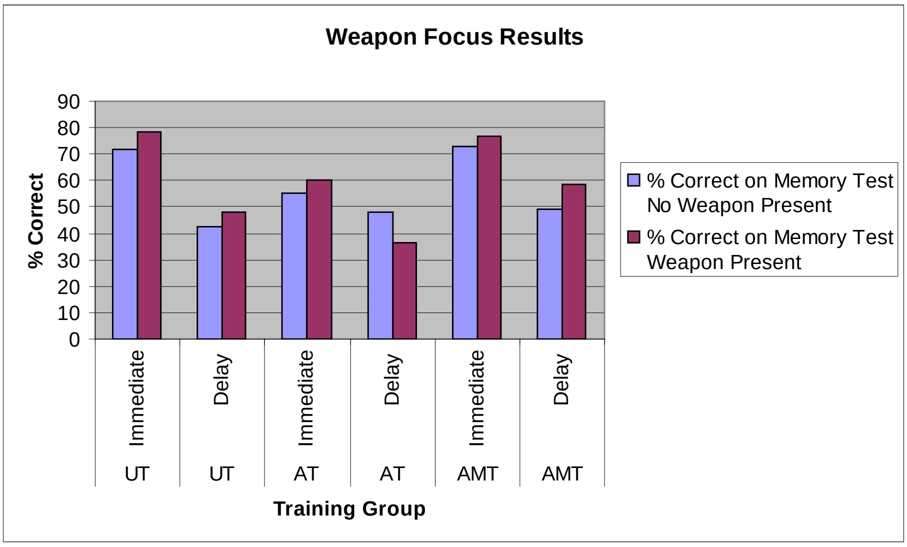

Figure 6. Percentage scores for correct answers on the memory test, for scenes with and scenes without a weapon present, for all six conditions.

EYE MOVEMENT

In order to assess the relationship between viewing behaviours and later recall average fixation counts in AOIs and average gaze duration for AOIs viewed, for correct and incorrect answers, was calculated for each participant and entered into a table of raw data (see appendix 15). The mean fixations and standard deviations for the six conditions are shown in table 3. Table 4 shows the mean gaze durations and standard deviations for all conditions. Gaze plots are a visual representation showing the gaze patterns and fixations of participants' allocation of attention to the crime scenes. Fixations are represented by circles with the size increasing as the duration of the fixation increases. Figure 7 shows examples of the gaze plots for participant's from each of the three groups (UT, AT and AMT).

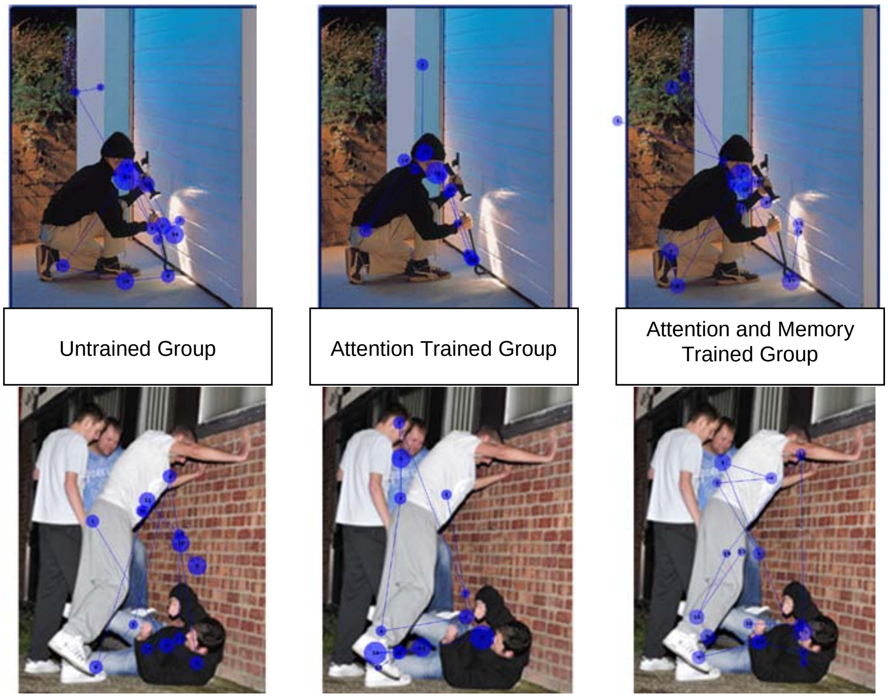

Figure 7. Gaze plots for participants from each training group (UT, AT, AMT).

Attention Trained

Fixations

Table 3. Mean fixation count and standard deviation for AOIs for the 6 conditions.

		Fixation Count for AOIs Correct Answers		**Fixation Count for AOIs Incorrect Answers**		
Group	**Test**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**N**
Untrained	Immediate	3.5	1.1	2.8	1.6	7
	Delay	4.1	1.7	3.1	1.5	8
	Total	3.8	1.4	2.9	1.5	15
Attention Trained	Immediate	3.4	1.0	2.9	0.6	9
	Delay	3.8	1.6	3.1	1.0	8
	Total	3.6	1.3	3.0	0.8	17
Attention and Memory Trained	Immediate	4.4	0.6	3.6	0.9	10
	Delay	4.4	0.8	3.3	0.8	9
	Total	4.4	0.7	3.5	0.9	19
Total	Immediate	3.8	1.0	3.1	1.1	26
	Delay	4.1	1.4	3.2	1.1	25
	Total	4.0	1.2	3.2	1.1	51

A mixed 3 (training group) x 2 (immediate vs. delay) x 2 (accuracy) ANOVA was used for analysis (see appendix 18). There was a significant difference [F (1, 45) = 27.802, p = 0.000] between the average number of fixations within AOIs for correct answers (M = 4.0, SD = 1.2) and incorrect answers (M = 3.2, SD = 1.1). A higher number of fixations equated to higher accuracy on the memory test. Therefore the hypothesis is accepted. There was no significant difference between the average number of fixations in AOIs for correct and incorrect answers across the training groups [F (2, 45) = 0.506, p = 0.607], or between participants taking the test immediately vs. delay [F (1, 45) = 0.541, p = 0.466]. Neither was there a significant interaction [F (2, 45) = 0.020, p = 0.981].

There was no significant main effect for the training groups [F (2, 45) = 2.251, p = 0.117]. No significant main effect was identified for the test condition [F (1, 45) = 0.605, p = 0.441]. There was also no significant interaction [F (2, 45) = 0.459, p = 0.635].

Gaze Durations

Table 4. Mean gaze duration and standard deviation for AOIs viewed for the 6 conditions.

		Gaze Duration (ms) for AOIs viewed Correct Answers		**Gaze Duration (ms) for AOIs viewed Incorrect Answers**		
Group	**Test**	**Mean**	**Standard Deviation**	**Mean**	**Standard Deviation**	**N**
Untrained	Immediate	955.8	398.0	853.1	476.6	7
	Delay	1134.0	423.6	998.0	535.9	8
	Total	1050.8	407.5	930.4	496.5	15
Attention Trained	Immediate	993.6	399.5	1177.9	715.6	9
	Delay	999.5	397.5	856.8	317.2	8
	Total	996.4	385.9	1026.8	572.1	17
Attention and Memory Trained	Immediate	1203.0	340.8	1043.1	391.0	10
	Delay	1275.2	275.4	1061.8	345.0	9
	Total	1237.2	305.2	1052.0	359.8	19
Total	Immediate	1064.0	379.1	1038.6	538.6	26
	Delay	1141.8	370.3	975.8	400.5	25
	Total	1102.1	373.1	1007.8	472.3	51

A mixed 3 (training group) x 2 (immediate vs. delay) x 2 (accuracy) ANOVA was used for analysis (see appendix 19). There was no significant difference [F (1, 45) = 2.393, p = 0.129] between the average gaze duration within AOIs viewed for correct answers (M = 1102.1, SD = 373.1) and incorrect answers (M = 1007.8, SD = 472.3). There was no significant difference between the gaze durations across the training groups [F (2, 45) = 1.038, p = 0.362], or between taking the test immediately vs. delay [F (1, 45) = 1.259, p = 0.268]. Neither was there a significant interaction [F (2, 45) = 0.595, p = 0.556].

There was no significant main effect for the training groups [F (2, 45) = 0.966, p = 0.388]. No significant main effect was identified for the test condition [F (1, 45) = 0.025, p = 0.876]. There was also no significant interaction [F (2, 45) = 0.760, p = 0.473]. The null hypothesis, therefore, has to be accepted.

Hot Spots

Fixation hot spots highlight the number of fixations allocated to areas of a scene for a collection of participants. The hot spots for participants were combined within each of the three training groups (UT, AT and AMT) for each of the ten test crime scene images. The following images highlight an example of these hot spots for two of the crime scenes. Where eye gaze has been fixated it is highlighted from green through to red. Red indicates the greatest number of fixations. It was hypothesised that participants in the AMT group would direct attention on crime related areas. Although the general spread of fixations is similar across all groups it is marginally evidenced, by the more intense hot spots, that attention was more directed and focussed by the AMT group on the faces of the offenders and victims.

Hot Spots – Crime Scene 2 No Weapon

Untrained Group

Attention Trained Group

Attention and Memory Trained Group

Hot Spots – Crime Scene 5 With Weapon

Untrained Group

Attention Trained Group

Attention and Memory Trained Group

DISCUSSION

This research has produced evidence suggesting that the level of training received did influence memory. However, this was not entirely as expected. Although the AMT group significantly outperformed the AT group (M = 10.4) they did not perform significantly different to the UT group. The UT group also performed significantly better than the AT group. The mean test scores were very similar for the UT group (M = 12.6) and the AMT group (M = 12.9). This pattern was consistent across both test conditions (immediate vs. delay). Notably, the UT group (M = 15.2) had marginally higher accuracy scores when tested immediately compared to the AMT group (M = 15.0). Whereas, the AMT group (M = 10.6) performed better than the UT group (M = 9.3) in the delay condition. Overall, however there was a significant difference between immediate recall (M = 14.0) and delayed recall (M = 9.6) across all participants. There was no identifiable interaction between the level of training received and test condition on accuracy.

Greater accuracy at immediate recall was as expected and consistent with previous findings (Devilly et al., 2007; Ebbesen and Rienick, 1998) indicating that a time delay negatively impacts eyewitness recollection. This is a critical implication for the use, and reliability, of eyewitnesses. Eyewitness evidence is heavily relied upon in court and a trial is often weeks, months or even years after the event. It would, therefore, be beneficial for cases to be presented in court as soon as practically possible after the event in order to ensure eyewitness reliability.

The failure of this research to successfully train individuals in the AMT group to become more accurate and reliable eyewitnesses is not in accordance with the model of expert memory (Gobet, 1998). Neither are the results consistent with the existing research (Christianson, Karlsson and Persson, 1998; Lindholm, Christianson and Karlsson, 1997) that highlights that Police Officers make better witnesses. These results are similar to those of Thomassin and Alain (1990) who recorded no difference in accuracy between Police recruits and medical students.

Importantly, none of the previous research attempted to train individuals per se. Past studies (e.g. Christianson, Karlsson and Persson, 1998; Lindholm, Christianson and Karlsson, 1997; Thomassin and Alain, 1990) were reliant on the training received by Police recruits and their past knowledge and experience. The research into expertise does focus on practice and existing knowledge (André and Fernand, 2008). The participants in this research did not have sufficient time to create schemas of crime scenes or build up a knowledge base, both of which are important in expert memory (Gobet and Simon, 2000). Outcomes may be different if civilians were compared directly with Police Officers. Further research, to assess comparisons, is essential when taking into consideration the general view that Police Officers are regarded as better witnesses (Lindholm, Christianson and Karlsson, 1997).

The weapon focus effect was not apparent in this experiment. There was no significant difference between accuracy for scenes where there was a weapon present than for scenes without a weapon. These findings do not correlate with the previous laboratory research into the weapon focus effect (Steblay, 1992). The mean test results emulate the findings of Cooper et al. (2002) highlighting that accuracy was higher for scenes with a weapon, although not significantly. This was true for all groups except the AT delay group where accuracy was higher for scenes without a weapon. Further investigation would be required to establish why the time delay impacted on accuracy in relation to the presence of a weapon for this group. The overall findings support those reported by Wagstaff et al. (2003) that a weapon has no significant effect on eyewitness accuracy.

In respect of the eye tracking data the only statistical significant result was that accuracy improved as the average number of fixations increased. There was no difference across groups, across test condition or an interaction for fixation count or gaze duration. The relationship between number of fixations and accuracy was as predicted and concurrent to existing research stating that scene memory is high for fixated items (Hollingworth, Williams and Henderson, 2001) and that the number of fixations correlates with recall (Melcher and Kowler, 2001). It also supports the link between attention and memory (e.g. Berman and Colby, 2009; Underwood et al., 2008; Wolfe, Horowitz and Michod, 2007).

There was no statistical relationship between gaze duration and accuracy. These findings are contradictory to the vast array of research that highlights a link between duration of fixation and accurate recollection (Melcher and Kowler, 2001; Rayner et al., 2009). The mean duration of fixation for the AOIs viewed were consistently higher, although not significant, for correct answers for all groups except the AT immediate group. The mean durations ranged from 853.1ms to 1275.2ms which is much higher than the 150ms of viewing required to sufficiently encode details of a scene (Rayner et al., 2009). They are also much greater than the average 300ms duration of fixation in scene perception (Hollingworth and Henderson, 2002).

It is interesting to note that the number of fixations was a predictor of accuracy but the duration of gaze was not. It, therefore, suggests that it is the number of times an object is attended to that improved accuracy and not simply the length of time spent looking at it. This could be attributed to the information being maintained within working memory through rehearsal. Repetition prevents decay (Smith et al., 2003) and in this instance the repeated viewing has ensured maintenance of the memory.

Therefore, the lack of association between gaze duration and accuracy may be a consequence of the level of processing applied by participants. It is possible that participants did not rate the information being viewed as requiring encoding in the same way an eyewitness would be aware of the importance of remembering such information. However, the AMT group were made aware that they were viewing the crime scenes as eyewitnesses and were expected to attend to and memorise relevant details. Despite this, their performance levels did not reflect this.

The AMT group did, interestingly, display differences in gaze patterns to the other two groups. This is displayed by the gaze plots and the hot spot comparisons. As predicted attention was directed and focussed upon crime specific details at a higher frequency amongst the AMT group. This finding is consistent with results indicated by Motter and Holsapple (2007) and Becker and Rasmussen (2008). Regardless of the increased duration and focussed direction of attention on these details this was not depicted in the analysis of fixation count, gaze duration and accuracy. These deductions are inferential only and further statistical analysis would prove beneficial for a more accurate examination of these findings. Sufficient analysis could be conducted by calculating the distant covered by each participant. ClearView software produces statistics stating the distance between each fixation (in pixels). Calculations can be applied to these figures to establish the overall distance covered during viewing. This analysis would allow comparisons to be drawn across the groups and establish whether the AMT group does use significantly different gaze patterns.

LIMITATIONS AND FURTHER RESEARCH

There are several identifiable limitations to this study, which if corrected could influence future outcomes. Firstly, the training process was not sufficient for participants in the AMT group to enhance their memory to expert level. They did not have the existing knowledge and built up schemas for crime scenes as would be expected of trained Police Officers. Ideally, this research should be conducted using Police Officers and civilians. This would provide a more accurate comparison between the accuracy of each group as eyewitnesses. The procedure used to train the AT group to ensure allocation of attention was on the crime scenes was not sufficient to ensure information was encoded into memory. It is apparent from the memory test results (AT group scoring significantly lower than the UT and AMT group) that by asking participants to pay attention to the image and look for the Manchester United Football logo it actually engaged them into a visual search task. Although this required allocation of attention, relevant information from the crime scenes was evidently not stored in memory. If this research was conducted with Police Officers and civilians this stage of the procedure would not be necessary. Therefore, a true comparison between the effects of training (in attention and memory) could be assessed.

The use of an eye tracker also presents inadequacies in the data. It is stated that the Tobii x50 eye tracker is competent at eye tracking even with the use of glasses and contact lenses (Tobii Technology, 2006). However, problems with calibration and recording presented for participants using glasses or contact lenses for corrected vision.

In addition, eye trackers are only able to record foveal eye movements (Duchowski, 2007) and research has evidenced that visual processing consists of foveal and extrafoveal attention (Saarinen, 1993). Subsequently, the recordings of fixation counts and gaze durations presented in this study may not be a complete reflection of eye movement.

There is evidence of cultural variations in eye movements during scene perception (Chua, Boland and Nisbett, 2005), a variable that was not considered in this research. Cultural differences are linked to subsequent recall and it is therefore an appropriate area for inclusion in eyewitness research. It is advised that in any future research ethnicity of participants is recorded to account for any potential cultural variations.

The fact that gaze duration and fixations counts were calculated from within defined AOIs presents potential defects in the data. Eye tracking can produce errors in gaze view. This can be as high as one degree (Tobii Technology, 2006). Consideration was allocated to this margin of area when defining the AOIs. However, the allowance may not have been sufficient to include all gaze data for every participant despite conducting calibration for each person.

The application of cued multiple choice questions in the memory test has evident implications. Effectively, the accuracy scores may be a consequence of pure chance as opposed to actual recall. As the scores are not consistently over 50% these results do not concur with those of Hollingworth and Henderson (2002) who established that scene memory is well above chance for attended objects. To identify the exact level of accuracy open ended questions would be advantageous. The presentation of the crime scenes images with the questions may result in recognition as opposed to recall. This is an important factor that reduces the ecological validity of the questioning technique. Unfortunately, it was felt the presentation of the images was necessary to identify which image the question related to.

To increase the ecological validity of this study the sequence of crime scene images could be replaced by video footage. This could either be actual footage or a reconstruction. This would provide enhanced imitation of the experiences of an eyewitness. It would also eradicate the necessity to present the images at recall stage.

In addition to this, measures of physiological responses could be recorded to assess the stress and anxiety levels of participants. Galvanic skin response and heart rate monitors would successfully identify any physiological differences between participants. Eye tracking software enables pupil dilation to be measured and this would enhance understanding of participants reactions to crime scenes. These measurements would aid comparisons between groups and establish if stress levels do impact eyewitness testimony as reported by Morgan III et al. (2004) and Valentine and Mesout (2009).

CONCLUSION

This research has provided supplementary insight into the memory of eyewitnesses. It has supported the existing literature highlighting the negative effect of a time delay on subsequent recall. It has questioned the weapon focus effect. The significant link between fixation count and accuracy has enhanced existing literature on the link between attention and memory. It has also provided insight into the possibility of training individuals to become better witnesses. Although there are a number of limitations to this study, improvements have been suggested. With these improvements progression could be made to establish an efficient procedure for training eyewitnesses. This would prove extremely beneficial for individuals readily in contact with crime scenes such as Police Officers. Further more it would add justification to the general belief that Police Officers are more reliable witnesses (Lindholm, Christianson and Karlsson, 1997).

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