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Research Paper

3D scanning a crime scene to enhance juror understanding of Bloodstain Pattern Analysis evidence

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ABSTRACT

There are numerous crime scene investigation applications of 3D scanning that have been previously documented. This paper documents the application of a 3D point cloud in the presentation of Bloodstain Pattern Analysis evidence to mock jurors. 150 mock jurors viewed a presentation of Bloodstain Pattern Analysis evidence from a murder trial in the UK. After viewing the evidence, the participants were tested on their knowledge of the evidence and repeated the test again 2 weeks later; to simulate criminal trial conditions; whereby there is a time lapse between the initial viewing of evidential material and deliberation. This paper found that the mock jurors who additionally viewed a 3D flythrough of a point cloud of the crime scene, better retained knowledge of the evidence over time, reported a greater ability to visualise the crime scene and had higher levels of interest in the evidence. Crucially, the 3D flythrough group did not report different levels of confidence in the accuracy of their memories of the evidence, nor different levels of emotional arousal to the group that viewed the evidence without the 3D presentation. Together, these findings suggest that 3D scanning of crime scenes, and the resultant point cloud's presentation to jurors, could add further value to the justice system when spatial information, such as Bloodstain Pattern Analysis evidence, is presented.

1. Introduction

Forensic applications of 3D scanning and modelling have been extensively documented [1–3] and include different methods, such as terrestrial laser scanning, structured blue-light scanning and photogrammetry, for the capture of geometric information for crime scene reconstruction [4–6], Road Traffic Collision (RTC) investigations [7] and shooting reconstructions [8]. Researchers have also transformed 3D point clouds of crime scenes into Virtual Reality (VR) environments for crime scene reconstructions [9] and to test suspects' concealed recognition [10]. With regards to Bloodstain Pattern Analysis (BPA), numerous publications have explored software that utilise 3D scanning to calculate an Area-of-Origin (AO) from blunt-force impact pattern, however the literature has not yet produced results that could satisfy judicial standards [11].

In the UK, an expert witness at a criminal trial will introduce their forensic discipline to the jury, define technical language and present their findings verbally. Jurors may have access to a written statement from the expert and crime scene photography within a traditional printed jury bundle. However, although much of the crime scene forensic evidence is 3-dimensional in nature, it is seldom presented in a 3D modality. Intuitively, presenting spatial information in a 3D modality (e.g., video flythroughs of the crime scene) should improve a jury's comprehension and memory of such forensic evidence; though this largely remains an assumption. Indeed, one previous study found no significant effects on mock juror verdict, confidence in the verdict, and understanding of technical language when 3D visualisation or 3D printed models were included in the presentation of forensic pathology evidence [12]. However, another study found that juror spatial memory was improved by a 3D reconstruction viewed in VR when compared with photographs alone [13]. BPA evidence often refers to spatial information, such as where someone has bled, sustained an injury, or been assaulted. Therefore, 3D visualisations could add value and improve juror understanding of BPA evidence. One of the aims of this current study was to explore this issue.

Another goal of the current work was to assess the impact of emotion

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on recall of BPA evidence. Visual materials that cause emotional arousal can significantly affect a juror's judgment [14,15]. However, emotion can also provide a critical function in constructing and evaluating narratives, assessing witness credibility, and issuing a verdict [16]. Different emotions affect the juror in various ways. Sadness may improve a juror's recall of testimonial inconsistencies, whilst anger may increase their feeling of certainty and confidence [17] but impair processing and bias their judgments [18], as greater confidence may not correlate with greater recall accuracy [19].

Therefore, this study examined how the inclusion of a 3D visualisation affected mock jurors' ability to accurately recall the facts from a BPA evidence presentation. Mock jurors reported how confident they were in the accuracy of their memories, their emotional state, their perceived ability to recall the crime scene, and their levels of interest and engagement with the task.

2. Method

2.1. Study design

This experimental study was a 2 (3D Evidence: Provided vs. Not Provided/Control) × 2 (Time point: Baseline vs. Delay) mixed design with time point as the within-subjects factor. The 3D evidence provided only to the test group was a video flythrough of a 3D point cloud of the crime scene: a 2:00 min video whereby a virtual camera moves through the 3D model of the scene. Two weeks after completion of the first session (Baseline condition), all participants were invited to complete the second session (Delayed condition) in their own time, with up to 8 days to do so. The time lapse between the sessions simulated a condition of a criminal trial; whereby jurors view evidence some time before their deliberation proceedings begin. The study was administered using Qualtrics®, an online survey platform. The dependant variables were self-reported emotional states, self-reported engagement with the material, crime scene information recall accuracy and recall confidence.

2.2. Participants

A total of 150 adults completed the study and were included in the analysis. Participants were recruited from a single cohort of first year BSc Psychology students from the primary author's institution to participate as mock jurors for this study. Participants were pseudo randomly assigned to the control group (i.e., no additional 3D evidence provided) or the test group (i.e., additional 3D evidence provided) to produce groups of equal size. The students were incentivised by the provision of course credit upon completion of the second session of the study.

2.3. Exclusions

Initially, 161 participants were recruited for session 1. However, six participants completed session 1 but did not complete session 2, and so their data was removed from the dataset. Qualtrics click counters monitored the number of mouse clicks a participant performed on each page. It was impossible to view the 2D evidence without recording 2 clicks on the 2D evidence page. If a participant registered only 1 click, this indicated that they did not view the 2D evidence. Four participants from the test group and 1 participant from the control group registered only one click on the 2D evidence page of the survey, meaning that they did not comply with experiment instructions and proceeded to the questionnaire without viewing the 2D evidence. Their responses were removed from the dataset. The resultant dataset was comprised of two complete sessions from 150 participants, 76 in the control and 74 within the test group.

2.4. Session 1 procedure

Participants completed the first session in a computer lab on the University campus. The lead researcher supervised the session and ensured that participants did not view each other's screens, nor copy or capture any of the forensic content. The test group's experience was identical to that of the control group, but with the addition of a 3D model to be viewed in the evidence presentation phase. Participants were briefed regarding their role as a mock juror which would involve viewing an evidence presentation involving bloody imagery of a real crime scene. After briefing, if participants provided consent, they proceeded.

2.4.1. Pre-presentation

After consenting, the participants were asked to indicate on a 5-point scale (from 1 = Lowest to 5 = Highest) the extent to which they were feeling: "*Anxious*", "*Calm*", "*Angry*", "*Sad*", "*Happy*", "*Disgusted*", "*Enthusiastic*".

2.4.2. Evidence presentation

All participants then viewed BPA evidence from a real crime scene. The crime scene, pictured in Fig. 1, was from 2021 and the subsequent murder enquiry had concluded in court months prior to the study's design phase. Written permission to use material from the investigation was obtained from multiple stakeholders at West Midlands Police, including the Senior Investigating Officer (SIO). Both the control and the test group viewed 15 slides which included a floorplan of the scene, 10 photographs of bloodstaining taken by the reporting scientist and 4 direct written quotes extracted from the expert witness' written statement for court. There were 263 written words in total, separated into 4 statements. This information provided the answers to the questions in the post-presentation phase.

The test group differed from the control group in that they also viewed a video flythrough of a 3D point cloud (2:00 min in length). During the initial investigation, the primary researcher scanned the crime scene with a 3D terrestrial laser scanner and provided the resultant 3D point clouds to members of the forensic investigation team. This scene was selected by the researcher for the study as it was deemed to be a representative BPA scene, with multiple common characteristics which were detailed in a previous paper [20]; the scene was indoors, there was one Injured Party (IP), there was evidence of sharp-force trauma and transfer, spatter, drip and cast-off stains were present. The video flythrough navigated a 3D point cloud of the scene and Fig. 2 displays a screenshot of this. The flythrough had a virtual camera moving through the crime scene, giving a first person perspective. The flightpath through the model was created by the researcher. The blood patterns were visible within the 3D model, but they were better defined in the photography. The aim of the 3D model was to contextualise what the participants had already observed from the 2D evidence and written testimony. Participants could pause the video and watch it and replay it but could not interact with the flightpath as they were viewing an MP4 video file.

The participants were free to review the evidence available to them as many times as they wished before proceeding.

2.4.3. Post-presentation

When the participants proceeded, they were prompted to close all windows of the evidence, which was monitored for compliance by the supervising researcher. The participants then repeated the emotions questionnaire from the pre-presentation phase.

The next series of questions assessed participants' perceived ability to remember the scene, as well as their engagement. These were reported on a 5-point scale (*1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree*). "*Please indicate the extent to which you agree with the following statements regarding the presentation you just viewed: 1. I can visualise and recall what the crime scene*

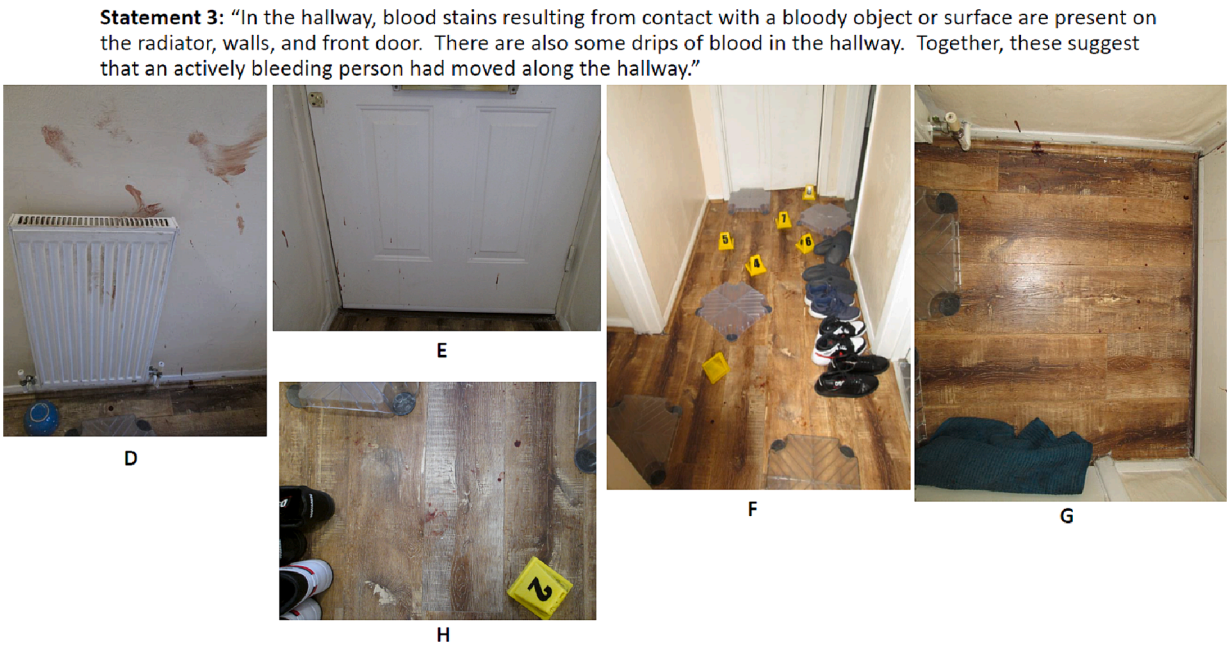

Fig. 1. An example slide of the BPA evidence presentation viewed by all participants.

Fig. 2. Screen capture of the 3D flythrough viewed by the test group.

looked like, 2. I can visualise and recall where blood was distributed in the crime scene, 3. The forensic materials gave me a comprehensive knowledge of what the crime scene was like, 4. I found the evidence to be interesting.".

Finally, the participants' completed a recognition memory test for the evidence they had examined. For eight statements, they were required to respond with either "*true*" or "*false*". Four of the statements were true, and four were false. For example, one of the true statements was "*The victim was stabbed*" which was explicitly written and read by all participants in the evidence presentation phase. Participants were also required to indicate their confidence in each answer on a 4-point scale (*1 = Unsure, 2 = Slightly unsure, 3 = Slightly confident, 4 = Highly confident*).

2.5. Session 2 procedure

Participants could access the second session 2 weeks after completion of the first and had 8 days to do so. The second Qualtrics survey was a shorter version of the first session with the omission of the evidence presentation, the emotion questionnaire, and the statements: *"3. The forensic materials gave me a comprehensive knowledge of what the crime scene was like and 4. I found the evidence to be interesting."* The purpose was to assess changes in the participants' responses over time, without additional presentation of the evidence, to simulate the process whereby a juror may initially view an expert witness' evidence several weeks before they are required to deliberate upon a verdict. The time interval of 2 weeks did not wholly simulate court conditions as murder trials can last many more weeks and months, however it was deemed an appropriate interval for the purpose of this study as the students did not view any further material regarding the case between completing sessions 1 and 2, meaning they were disengaged from the subject matter within the time interval which would have impacted their knowledge retention. No evidence was re-viewed in the second session and the participants were able to complete this session independently, on any device. Finally, participants read a debriefing statement and were invited to contact the lead researcher if they had questions or required further information about the study.

Each participant was allocated a unique response ID code that was used to link their session 1 and session 2 data. However, the lead researcher did not have access to the University database which could identify individuals based on their response ID code and once the data from both sessions was linked during analysis, the response ID was deleted. Therefore, all data collected was anonymous.

2.6. Planned analysis

The data was analysed with two-way mixed ANOVAs, independent samples t-tests and a Welch *t*-test; which was used when data were non-parametric [21]. Bonferroni corrections [22] were applied where similar data was analysed with multiple statistical tests. For example, test confidence and test score were directly linked in the questionnaire; therefore, corrections were applied. Finally, effects sizes are reported as either partial eta squared (η_p^2) for ANOVAs or Cohen's d (d) for t-tests which can be interpreted as small ($\eta_p^2 = 0.01$, $d = 0.2$), medium ($\eta_p^2 = 0.06$, $d = 0.5$) or large ($\eta_p^2 = 0.14$, $d = 0.8$) [23].

3. Results

3.1. Memory test scores

Participants could score between 0–8 on the memory test. Participants' mean memory test scores at time points 1 and 2 are illustrated in Fig. 3. A corrected ($p/2$) 2 (Time point) x 2 (Group) mixed ANOVA was used to analyse the accuracy of participants' memories of the evidence.

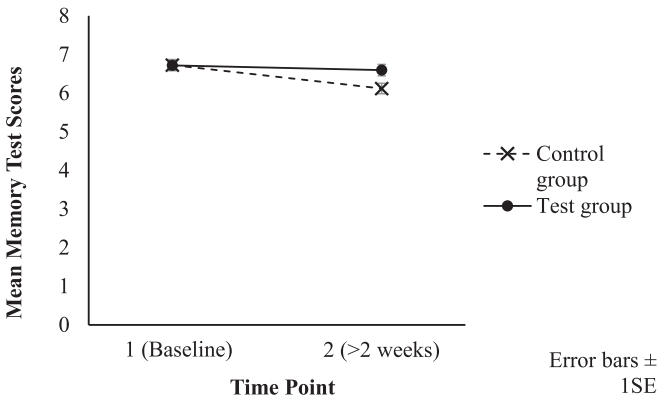

Fig. 3. Mean memory test scores at time points 1 and 2.

There was a statistically significant interaction between group and time point on memory test score, $F(1, 148) = 6.299$, $p = .013$, $\eta_p^2 = .041$. Specifically, there was no significant difference between the test and control groups for memory test score at baseline (Mean Difference $MD = .007$, $SE = .10$, $p = .969$, $d < 0.01$). However, test scores at the 2-week delay (Time point 2) were greater in the test group than in the control group ($MD = 0.48$, $SE = .10$, $p = .020$, $d = 0.41$). For the control group, mean test score was significantly lower following the 2-week delay ($MD = 0.605$, $SE = 0.141$, $p < .001$, $d = 0.49$), whereas it was not significantly different after the 2-week delay for the test group ($MD = 0.122$, $SE = 0.141$, $p = .374$, $d = 0.10$).

3.2. Memory confidence

Participants rated their confidence in their test answers on a 4-point scale (1 = Unsure, to 4 = Highly confident). Fig. 4 shows participants' mean confidence ratings at each time point. A corrected ($p/2$) 2 (Time point) x 2 (Group) mixed ANOVA was used to analyse participants' confidence ratings. There was no significant interaction between group and time point on mean confidence, $F(1, 148) = 1.151$, $p = .285$, $\eta_p^2 = .008$. There was a main effect of time point showing that mean confidence was significantly lower after the 2-week delay ($MD = .265$, [95 % CI, 0.198—0.331], $F(1, 148) = 62.08$, $p < .001$, $\eta_p^2 = .296$). No main effect of group was found for mean confidence $F(1, 148) = .277$, $p = .599$, $\eta_p^2 = .002$.

3.3. Perceived memory

Participants were asked to rate the extent to which they agreed with the two statements, '*I can visualise and recall what the crime scene looked like*' and '*I can visualise and recall where blood was distributed in the crime scene*' on a 5-point scale at time points 1 and 2. The ratings for both statements were combined in both instances to form a perceived memory score, thereby producing a value between 2 and 10. The mean perceived memory scores are shown in Fig. 5. With this perceived memory score, a two-way mixed ANOVA was conducted. There was no significant interaction between group and time point on perceived memory scores, $F(1, 148) = .022$, $p = .882$, $\eta_p^2 \sim 0$. However, there was a main effect of time point whereby perceived memory scores were 0.887 [95 % CI,.641—1.133] lower in the second test than in the first, $F(1, 148) = 50.61$, $p < .001$, $\eta_p^2 = .255$. Furthermore, there was a main effect of group whereby test group participants reported scores that were on average 0.371 [95 % CI,.014 −.728] higher than the control group, $F(1, 148) = 4.22$, $p = .042$, $\eta_p^2 = .028$.

3.4. Self-reported engagement

Participants in the test group self-reported higher agreement ratings for the statement "*I found the evidence to be interesting*" than participants in the control group, ($MD = 0.41$, $SE \pm 0.14$, *Welch* $t(137) = 2.873$, $p = .005$, $d = .46$). Participants in the test group self-reported marginally greater ratings to the statement "*The forensic materials gave me a comprehensive knowledge of what the crime scene was like*", ($MD = 0.27$, SE $\pm$ 0.13, $t(148) = 2.174$, $p = .031$, $d = .07$) however note that this is below the corrected Bonferroni threshold.

Seven corrected ($p/7$) independent samples t-tests found no statistically significant differences between the control and test group in any of the 7 reported emotion changes. None of the p-values for emotion changes were smaller than p = 0.05, therefore the results would have been the same even without the correction ($p/7$).

4. Discussion

This experiment tested how including a 3D presentation in a BPA evidence presentation affected juror memory, confidence, engagement, and emotional change. The test group that viewed a 3D flythrough of the crime scene, in addition to the BPA evidence, correctly remembered more of the facts over time, reported higher levels of interest in the evidence, as well as a greater ability to visualise and remember the crime scene than the control group. There was no difference in confidence between groups, and inclusion of the 3D modelling did not result in different emotional changes.

The ecological validity of mock juror studies comprised wholly of undergraduate students has been criticised [24] and is something the reader should consider when reviewing the results of this study. However, a *meta*-analysis [25] found few differences between community and student-based samples. The participants in this study acted as mock jurors to the extent that they viewed forensic evidence as laypersons and were tested on their knowledge of the evidence. They did not deliberate

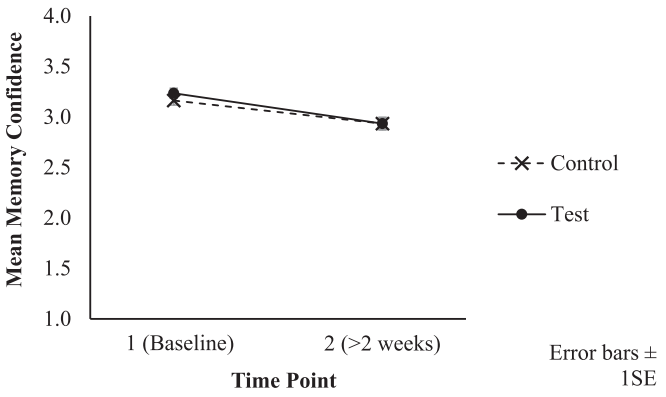

Fig. 4. Mean confidence ratings at time points 1 and 2.

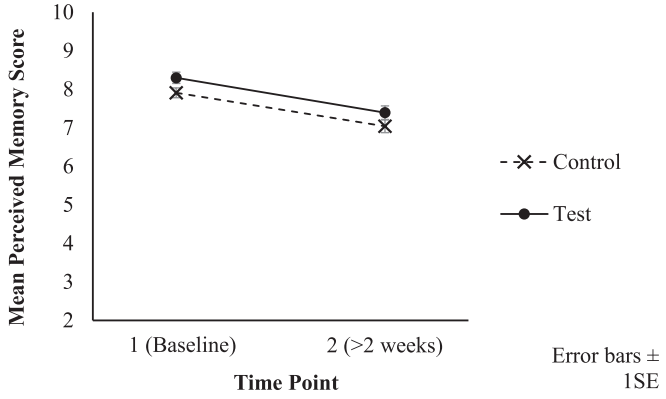

Fig. 5. Mean perceived memory scores at time points 1 and 2.

with each other, nor were they asked to assess guilt. For the purposes of testing knowledge retention and emotional changes between test and control groups, this sample was deemed appropriate by the researchers.

The test group were more likely to remember the evidence correctly than the control group in session 2 and. This suggests that the inclusion of 3D visualisation in a BPA evidence presentation could help jurors to better retain knowledge over time. This could be crucial in a long trial, where a jury may need to recall facts from the trial many weeks or months later in deliberation, and attrition of knowledge is likely to be a factor. The test group participants' significantly better memory test performance was coupled with a higher interest in the evidence itself (i.e., higher agreement with the statement, "*I found the evidence to be interesting*"). If the test group found the presentation that included 3D visualisation more engaging, it could explain the greater performance in session 2's memory test. Again, in a long trial, keeping a jury engaged with the evidence could be critical. Alternatively, the test group viewed 2:00 min of additional material which could potentially have contributed to their improved knowledge retention in session 2. However, if this was the cause of the effect in session 2, it did not have a significant effect on the jurors' knowledge retention in session 1. This study was limited, in that the subjects were tested on only 8 statements with a 50/50 chance of picking the correct answer. However, a significant difference with medium effect sizes in session 2 was observed with the test group scoring higher. Future work could increase the scale of the testing, with more questions from different subject areas and use of multiple choice or written answers, and then observe whether differences between test and control groups persist or change in scale.

Whilst it is desirable that jurors feel confident in their knowledge of the facts, it is equally important that the evidence they observe does not make them more certain when their judgments are wrong. Confidence in a false recollection of fact could be more damaging to a deliberation process than low confidence in the truth. Our findings for confidence mirrored those found in another study [12] that showed no significant effect on confidence with the inclusion of 3D modelling. The findings from these studies suggest that confidence is not significantly affected by the inclusion of 3D modelling, which would help justify its use in the judicial process without the fear of biasing the jurors. However, future work could examine whether differences in confidence occur when further complexities are introduced into experimental parameters.

There was no significant difference between the two groups for agreement with the statement "*The forensic materials gave me a comprehensive knowledge of what the crime scene was like*" however the test group reported significantly higher recall scores (obtained from the two statements: '*I can visualise and recall what the crime scene looked like'* and '*I can visualise and recall where blood was distributed in the crime scene*'). This appears to make sense when taking into consideration the no significant difference in confidence between groups. The test group did not feel as if the evidence was any more or less comprehensive than the control group, thus confidence in their test answers was not significantly different. However, their perceived ability to recall the scene and its details was significantly greater at both time points, and this also coincided with a greater retention of knowledge in session 2, illustrated by significantly better performances in session 2's test.

Previous studies have reported on the impact of anger, disgust, and anxiety on mock jurors' conviction rates [26,27]. Another study suggested that future research could explore disgust and anxiety and how they affect juror processes [18]. This study did not aim to prove how viewing BPA evidence alters different emotions. Due to the nature of the study design, the participants were introduced to the evidence in the middle of an undergraduate study week, thus after viewing and reading information regarding a real person's violent death, emotional change would inevitably be evoked. The data was therefore analysed to compare the effects of viewing 3D modelling on mock jurors' emotional change. As the test group did not significantly differ in any emotional change from the control group, it suggests that the inclusion of 3D visualisation within BPA evidence presentation will not introduce emotional bias to any degree greater than is already present in currently established court practices.

Courts in the UK generally still operate with limited technology which may contribute to barriers to the inclusion of interactive 3D models in criminal proceedings. However, the conversion of a 3D model to a video flythrough format would allow any court room with a television screen, which are commonplace, to present a video file of the 3D modelling to the court with relative ease. Whilst not every police force in the UK may have access to 3D scanners, forces already deploying them as a standard data capture method at homicide scenes may seek to provide the 3D models to expert witnesses to improve the cost-benefit of investing in the 3D capture technology.

5. Conclusion

Inclusion of a 3D visualisation within BPA evidence presentation may prove useful to the judicial system when physical scene visitation by the jury is impractical. This study suggests that juror knowledge retention improves with the inclusion of 3D visualisation without significantly altering their emotional state compared with the status quo of verbal descriptions and photography. This paper recommends that BPA expert witnesses make use of 3D crime scene models in their evidence presentations, if the material is readily available to them. If 3D scanning of the scene for this purpose would require further monetary expense, a cost-benefit decision should be made to determine whether the case would proportionately benefit from the material being presented in a 3D context. Courts may endeavour to accommodate the inclusion of digital presentations, and the inclusion of 3D modelling if available, especially if further research continues to prove a value added in knowledge retention, which will ultimately contribute to the delivery of justice. Finally, future work could expand upon this study to test the effects of presenting other types of evidence to mock jurors in a 3D modality, with particular focus on those with spatial factors and complexities.

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Ethical approval**:** Ethical approval was sought for two independent but related studies. Part 1 "3D modelling for secondary Bloodstain Pattern Analysis" was deployed as a survey, but responses were extremely limited and the study was not completed. Part 2 "3D modelling for Bloodstain Pattern Analysis evidence presentation" formed this mock juror study. This study was granted full ethical approval on Monday 31st October 2022 by the author's institution's Biomedical & Scientific Research Ethics Committee (BSREC). Application reference: BSREC 161/21-22. All participants were briefed on the nature of the study with a Participation Information Leaflet. The PIL explained that participation was voluntary, that withdrawal could occur at any time and that data would be anonymised immediately upon completion of the survey. After reading the PIL, participants were asked if they consented to taking part in the study.

CRediT authorship contribution statement

Patrick H. Home: Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Danielle G. Norman:** Conceptualization, Methodology, Formal analysis, Writing – review & editing. **Kimberley Wade:** Conceptualization, Data curation, Writing – review & editing. **Emily Spearing:** Methodology. **Mark A. Williams:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial

interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] U. Buck, S. Naether, B. Räss, C. Jackowski, M.J. Thali, Accident or homicide – Virtual crime scene reconstruction using 3D methods, Forensic Sci. Int. 225 (1) (2013) 75–84, https://doi.org/10.1016/j.forsciint.2012.05.015.

[2] K. Alsop, D.G. Norman, W. Baier, J. Colclough, M.A. Williams, Advantages of micro-CT in the case of a complex dismemberment, J. Forensic Sci. 67 (3) (2022) 1258–1266, https://doi.org/10.1111/1556-4029.15007.

[3] M.A. Maneli, O.E. Isafiade, 3D forensic crime scene reconstruction involving immersive technology: a systematic literature review, IEEE Access 10 (2022) 88821–88857, https://doi.org/10.1109/ACCESS.2022.3199437.

[4] R. Tredinnick, S. Smith, K. Ponto, A cost-benefit analysis of 3D scanning technology for crime scene investigation, Forensic Science International: Reports 1 (2019) 100025, https://doi.org/10.1016/j.fsir.2019.100025.

[5] W. Baier, M.J. Donnelly, M. Payne, M.A. Williams, A holistic multi-scale approach to using 3D scanning technology in accident reconstruction, J. Forensic Sci. 65 (5) (2020) 1774–1778, https://doi.org/10.1111/1556-4029.14405.

[6] R. Somma, A. Altadonna, F. Cucinotta, M. Raffaele, F. Salmeri, G. Baldino, E. Ventura Spagnolo, D. Sapienza, The technologies of Laser scanning and structured blue light scanning applied to criminal investigation: case studies, Atti Della Accademia Peloritana Dei Pericolanti. Classe Di Scienze Fisiche, Matematiche e Naturali 101 (S1) (2023) A15, https://doi.org/10.1478/AAPP.101S1A15.

[7] R. Kamnik, M. Nekrep Perc, D. Topolšek, Using the scanners and drone for comparison of point cloud accuracy at traffic accident analysis, Accid. Anal. Prev. 135 (2020) 105391, https://doi.org/10.1016/j.aap.2019.105391.

[8] C.E. Chase, E. Liscio, 123120 technical note: validation of recon-3D, iPhone LiDAR for bullet trajectory documentation, Forensic Sci. Int. 111787 (2023), https://doi.org/10.1016/j.forsciint.2023.111787.

[9] Y. Sang-hun, G. Thomson, V. Rinaldi, C. Rowland, N.N. Daeid, Development of a dundee ground truth imaging protocol for recording indoor crime scenes to facilitate virtual reality reconstruction, Sci. Justice 63 (2) (2023) 238–250, https://doi.org/10.1016/j.scijus.2023.01.001.

[10] D.G. Norman, K.A. Wade, M.A. Williams, D.G. Watson, Caught virtually lying - crime scenes in virtual reality help to expose suspects' concealed recognition, J. Appl. Res. Mem. Cogn. 9 (1) (2020) 118–127, https://doi.org/10.1016/j.jarmac.2019.12.008.

[11] P.H. Home, D.G. Norman, M.A. Williams, Software for the trajectory analysis of blood-drops: a systematic review, Forensic Sci. Int. 328 (2021) 110992, https://doi.org/10.1016/j.forsciint.2021.110992.

[12] D. Errickson, H. Fawcett, T.J.U. Thompson, A. Campbell, The effect of different imaging techniques for the visualisation of evidence in court on jury comprehension, Int. J. Leg. Med. 134 (4) (2020) 1451–1455, https://doi.org/10.1007/s00414-019-02221-y.

[13] C. Reichherzer, A. Cunningham, J. Walsh, M. Kohler, M. Billinghurst, B.H. Thomas, Narrative and spatial memory for jury viewings in a reconstructed virtual environment, IEEE Trans. Vis. Comput. Graph. 24 (11) (2018) 2917–2926, https://doi.org/10.1109/TVCG.2018.2868569.

[14] E. Oliver, W. Griffitt, Emotional arousal and 'objective' judgment, Bull. Psychon. Soc. 8 (5) (1976) 399–400, https://doi.org/10.3758/BF03335179.

[15] K.S. Douglas, D.R. Lyon, J.R.P. Ogloff, The impact of graphic photographic evidence on mock jurors' decisions in a murder trial: probative or prejudicial? Law Hum Behav. 21 (5) (1997) 485–501.

[16] T.E. Pettys, The emotional juror symposium: ethics and evidence: V. the use of prejudicial evidence, Retrieved from, Fordham Law Rev. 76 (3) (2007) 1609–1640, https://heinonline.org/HOL/P?h=hein.journals/flr76&i=1625.

[17] N. Feigenson, Jurors' emotions and judgments of legal responsibility and blame: what does the experimental research tell us? Emot. Rev. 8 (1) (2015) 26–31, https://doi.org/10.1177/1754073915601223.

[18] M.E. Pritchard, J.M. Keenan, Memory monitoring in mock jurors, J. Exp. Psychol. Appl. 5 (2) (1999) 152–168, https://doi.org/10.1037/1076-898X.5.2.152.

[19] C. Semmler, N. Brewer, Effects of mood and emotion on juror processing and judgments, Behav. Sci. Law 20 (4) (2002) 423–436, https://doi.org/10.1002/bsl.502.

[20] P.H. Home, D.G. Norman, A. Palmer, P. Field, M.A. Williams, Quantifying forensic investigations involving bloodstain pattern analysis within the UK, Forensic Sci. Int. 339 (2022) 111424, https://doi.org/10.1016/j.forsciint.2022.111424.

[21] M. Delacre, D. Lakens, C. Leys, Why psychologists should by default use Welch's t-test instead of student's t-test, International Review of Social Psychology 30 (1) (2017) 92–101, https://doi.org/10.5334/irsp.82.

[22] Napierala, M.A. (2012) 'What is the Bonferroni correction?', AAOS Now, Apr, 40, available: https://link.gale.com/apps/doc/A288979427/HRCA?u=anon~cd69f14e&sid=googleScholar&xid=ae13c395.

[23] C.C. Serdar, M. Cihan, D. Yücel, M.A. Serdar, Sample size, power and effect size revisited: simplified and practical approaches in pre-clinical, clinical and laboratory studies, Biochemia Medica 31 (1) (2021) 27–53.

[24] R.L. Wiener, D.A. Krauss, J.D. Lieberman, Mock jury research: where do we go from here? Behav. Sci. Law 29 (3) (2011) 467–479, https://doi.org/10.1002/bsl.989.

[25] B.H. Bornstein, J.M. Golding, J. Neuschatz, C. Kimbrough, K. Reed, C. Magyarics, K. Luecht, Mock juror sampling issues in jury simulation research: a meta-analysis, Law Hum Behav. 41 (1) (2017) 13–28, https://doi.org/10.1037/lhb0000223.

[26] D.A. Bright, J. Goodman-Delahunty, Gruesome evidence and emotion: anger, blame, and jury decision-making, Law Hum Behav. 30 (2) (2006) 183–202, https://doi.org/10.1007/s10979-006-9027-y.

[27] J.M. Salerno, L.C. Peter-Hagene, The interactive effect of anger and disgust on moral outrage and judgments, Psychol. Sci. 24 (10) (2013) 2069–2078, https://doi.org/10.1177/0956797613486988.