Title

Investigating The Visibility Of Subjects In Night-Time Footage Captured By Ring Video Doorbells.

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Abstract

Surveillance in digital forensics is ever changing and improving. However, there are some common issues that mean different surveillance devices are not as effective as they could be. Examples include, position, weather, light levels during night-time and distance. Whilst these issues have been explored for varying devices such as Closed-Circuit Television, there is limited research to how they affect Smart Doorbells, specifically Ring Video Doorbells. This research aims to bridge that gap and investigate if aspects of varying subjects can be identified in night-time footage captured on three different Ring Video Doorbells. These three, varied in video quality and night vision capabilities with some using infrared and other utilising coloured night vision. The main variables investigated were the night-vision, distance and whether the visibility of findings could be further improved using the ‘Levels’ tool in Amped FIVE software. This was then discussed within the context of future digital forensics. The research was put to participants and found that distance did affect the visibility and that the coloured night vision was the preferable option. The enhancements faced issues regarding reflection and were not as successful as assumed to be, however, in certain conditions, it did make an improvement. It was then discussed how these findings may be of police interest and could be integrated into existing knowledge within digital forensics.

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Introduction

1.1. What is Digital Forensics?

Digital Forensics can be described as the identification, forensic analysis, and documentation of any digital device, (Gogolin, G, 2013). It is a branch of Forensic Science that is rapidly expanding and becoming more prevalent in criminal investigations each year, (Interpol, 2024). Devices that are commonly analysed in digital forensics include mobile phones, computers, tablets and external storage devices such as USB and SD cards. However, digital forensics reaches into all devices and therefore even medical devices such as pacemakers or gaming consoles may be analysed, (ForensicFocus, 2023). Other areas also included are image or video enhancement, body mapping, facial recognition, crime scene reconstruction and surveillance devices.

1.2. Surveillance in Digital Forensics

Surveillance is all around, the UK Parliament, in 2009, stated it can be described as ‘monitoring behaviour of people, objects and systems. In 2022, Anekanta Consulting produced a report that stated there are an estimated 21.1 million CCTV cameras in the United Kingdom, compared to 6 million in 2013. Despite this, 99% of these cameras are in the private sector, with 70% of those used to prevent crime, totalling to 15 million cameras. CCTV or Closed-Circuit Television are cameras that are used for security purposes and often to prevent crime by deterring criminals or recording instances to provide evidence in criminal investigations, (College of Policing, 2021).

Surveillance also consists of police ANPR camera or Automatic Number Plate Recognition. Police.uk (2024) discuss how they use ANPR to observe criminal activity, as it tracks each number plate and scans their database to check whether it has been flagged as a vehicle of interest; this is useful in missing persons investigations, stolen vehicles, and other major crimes.

A contemporary addition to digital forensic surveillance are drones. West Midlands Police (2024) states that drones are unmanned aerial vehicles and how their drones have high-definition cameras and thermal imaging devices to assist in investigations.

They allow for scanning of large areas in a small amount of time such as football games or protests as well as major threats such as a terrorist incident.

On the other hand, smart Doorbells are a newer addition to digital forensics and the surveillance world. In 2021, Strategy Analytics reported that Ring sold upwards of 1.7 million video doorbells and further estimated that 12 million video doorbells of all brands were purchased globally. They are utilised to deter criminal and prevent crime. Forensic Expert (2019) lists some advantages of smart doorbells, including that they are affordable, with the cheapest battery-powered Ring Video Doorbell being £99.99 and the most recent release being £159.99 (Ring, 2024). They are also easy to install, being either drilled into walls, inserted into existing peepholes, or a click-in mechanism. Footage can be efficiently downloaded from the application from a mobile phone and handed over to police for use in criminal investigations, which is becoming more frequently requested.

1.3. Literature Review – Common Issues of Surveillance

This literature review will discuss the common issues with surveillance and highlight the gap in the literature which is addressed in this research project. As digital forensics progress, the surveillance all around us increases. As a result, some of the public believes their existence violates their privacy. Discussed by Macnish, K in 2024, he states the issue is the power imbalance between those being recorded and those watching. Despite this, a code of practice released by the Home Office in 2013 contests this, and states how they wish to instil confidence in the public that surveillance is there to protect them and not to spy on them.

Concerning common issues with surveillance itself, the location of the device such as the CCTV can be a big issue, discussed by Kevel, H and Sasse, A in 2006. Poor placement of the camera, which may not suit the environment it was installed in, can result in lack of footage that can be used in an investigation. A research paper conducted in South Korea explores this; Kweon, J and Lee, K.H in 2018, proposed a placement model for CCTV cameras to monitor criminal activity more effectively, They described the optimal position for the camera with reference to mechanical operation for effective use in student safe zones. Moreover, a paper conducted by Seckiner, D,

et al in 2018 discusses variables that can cause distortion to CCTV, one of them being if lens is dirty. This can cause issues with the footage recorded and as a result distort it. Another issue could be if the surveillance device is damaged. If the lens has been damaged, then the footage may still be recorded but there will be issues that can cause disrupted visibility. Motion blur is also a common factor that can cause issues with surveillance devices, (Chen, C.H, et al, 2008). If an object is moving, the subject may be blurred in the frame and therefore unobservable. Distance is also a factor in the capture of surveillance, a study conducted by Grgic, M., Delac, K. & Grgic, S in 2009, focused on creating a database of images for facial recognition research with five cameras that recorded an individual from three separate distances. They discovered distance influenced their results because of the viewing angle changing each time and lowered the image resolution.

Another factor that can affect devices which are outside is the weather. Poor weather conditions can affect the video quality, this includes, rain, snow, and fog, (Engineered Alarm Solutions, 2024). Moreover, filming at night-time compared to daytime can significantly affect results. Many cameras now have some form of night-vision, whether this is infrared or coloured night vision. Infrared night vision as described by National Geographic in 2023, states that it uses infrared waves and measures the heat that is radiated from something and turns it into an electrical signal and outputs an image. However, this image that is produced contains no colour information. On the other hand, coloured night vision works by using sensitive light sensors and near-infrared light to produce image in colour rather than greyscale, (HomeTheatreReview, 2023). The camera quality of the surveillance device itself can determine whether footage is usable, older cameras tend to have lower resolution and therefore are unable to record footage in a quality that a modern-day criminal investigation requires. This point is discussed by Chaisorn, L and Wong, Y in 2013 where they mention how not only is general resolution low in these surveillance cameras but also cost to replace or upgrade them is often an issue. Additionally, problems that may be created with the need for an increased storage capacity that coincides with upgrading video quality.

Whilst the above issues have been identified as common problems faced with general surveillance devices, the literature that discusses these with regards to smart doorbells or Ring Doorbells specifically is limited. As a result, this research aims to bridge the

gap and assess the visibility of varying subjects in night-time footage and investigate how distance and the different night-vision capabilities of three different Ring doorbells affect this. It will then be evaluated whether the footage can be enhanced using the 'Levels' tool in Amped FIVE to improve the visibility further.

A recent study conducted by Gvozdanoić, M, et al, in 2023, observes video footage of a number plate and utilises Amped FIVE and various tools to enhance the image for the purpose of identification. This footage was recorded at daytime and is of a moving vehicle and focuses on deblurring filters as well as adjusting the contrast and brightness tool to improve the image visibility. The research is successful and demonstrates one use of Amped FIVE's various filters. This is just one example of how Amped FIVE can be utilised in digital forensics.

Moreover, in the further research section of this paper, it is suggested that the use of enhancement tools could make the analysis of security camera footage more effective whilst addressing issues such as poor resolution, lack of quality lighting and object distance whilst specifically focusing on number plates, suspects, and objects.

Whilst this research project does not address an automated process, it does investigate these variables and the affect that they have on the identification of various elements which has been as highlighted as an area that needs further investigation.

1.4. Case Study

A modern example of the important usage of digital forensics in criminal investigations is the kidnapping and murder of Sarah Everard. The crime took place on the 3rd of March 2021, when 33-year-old Sarah Everard was walking home in Clapham, London; she was approached by Wayne Couzens, an off-duty police officer who wrongly arrested her for violation of COVID-19 guidelines. Couzens was found to have sexually assaulted and murdered Sarah Everard before dumping her belongings and setting her remains alight in the woods. He was arrested on the 9th of March for his crimes, and he was sentenced to a whole life order.

Sky News (2024) detailed that some of the main pieces of evidence in the case was digital evidence. The first usage was CCTV that filmed Sarah leaving a supermarket before heading to a friend's house, as well as footage from a Ring Doorbell camera. Richard Hale from Birmingham City University (2024) discusses the use of cell site analysis in the case as phone records were retrieved that stated she was on a 13-minute phone call to her boyfriend whilst walking home and she was then captured twice on CCTV walking home alone, and the same camera captured Couzen's Vauxhall passing and heading in the same direction as Sarah. After, CCTV on a bus captured the conversation between the two. The car was then recorded being driven away from the location where they both stood. Wayne Couzens route was then tracked using ANPR cameras and further cell-site analysis. Analysis of phone records showed he travelled to Ashford in the early hours of March 4th. It is in this location Sarah Everard's body was discovered. He later was recorded on CCTV purchasing two green rubble bags at B&Q purchasing a petrol can. The elaborate digital evidence in this case allowed for investigators to piece together exact moments of Sarah's disappearance, her interaction with Couzens and the route he took in the following hours leading to the discovery of her remains and led to Wayne Couzens' arrest on the 9th of March.

1.5. Ring Video Doorbells

Smart Doorbells are a contemporary edition to digital forensics. Their focus is on evolving the traditional doorbell and upgrading home security, (OxygenForensics, 2021). There are many well-known brands on the market, such as Amazon Ring, Sky Protect, Reolink, and Google Nest. Ring LLC is a company associated with Amazon that create motion sensor cameras and video doorbells. Moye (2023) discusses how the Ring Video Doorbell was released in 2014; the devices detect motion, record video and audio as well as provide a live feed from its device to the brand's application downloaded onto the user's device, (De Looper, 2023). Ring in 2023, described how users can utilise their software by receiving notifications on a mobile phone, tablet or PC and can 'see, hear and speak' to anyone in present time. Users can access the footage on the app and download the videos for up to 30 days as they get stored on a cloud server. Additionally, users can upgrade to a subscription, entitled 'Ring Protect' which allows footage to be stored in the cloud server for up to 180 days. Ring Video

Doorbells come either wired or wireless and are charged via a battery. They differ in video quality as the highest currently being offered is the Battery Video Doorbell Plus which has video quality of up to 1536p and in high definition, whilst the 1st Generation doorbell only has a video quality of 720p, without high definition. Another difference is the night-vision that each offer. The Video Doorbell Plus offers coloured night vision whilst the other wireless doorbells offer infrared night vision.

1.6. Amped FIVE

Amped FIVE is a software created for the purpose of image enhancement and analysis as well as for video footage. Amped Software (2023) states it was founded in 2008 and its products are used in forensic, security and investigation environments globally. Amped FIVE is just one of the six software's created by the company, others include: Amped Authenticate, for image tampering detection; Amped DVRConv, Amped Replay and Amped Engine, which all focus on either playing or converting closed circuit television footage and other digital video recordings; as well as Amped Training, a software to gain knowledge in image and video analysis. Amped FIVE includes features such as the ability to convert media, to analyse frame by frame, enhance using 140 filters and tools and as well as exporting and generating a report of the process completed.

1.7. Project Outline

Aim

The aim of this research project is to investigate if aspects of varying subjects can be identified in night-time footage captured on three different Ring Video Doorbells.

Objectives

1. Explore how distance affects the visibility of subjects recorded on Ring Video Doorbells.
2. Evaluate the use of infrared night vision against colour night vision in improving visibility in night-time footage recorded by Ring Video Doorbells.
3. Investigate the use of the 'Levels' tool in Amped FIVE to see if visibility can be improved.

4. Discuss the findings of this research within the context of future digital forensic investigations.

Hypotheses

1.
    a. The visibility will improve when the distance between the subject and the camera is decreased.
    b. The visibility will not improve when the distance between the subject and the camera is decreased.
2.
    a. The visibility will improve when images are captured using coloured night-vision as opposed to infrared night vision.
    b. The visibility will improve when images are captured using coloured night-vision as opposed to infrared night vision.

3.
    a. Enhancements completed via Amped FIVE will improve the visibility of the subjects.
    b. Enhancements completed via Amped FIVE will not improve the visibility of the subjects.

Method

Before beginning research, an ethics form was completed. A disclaimer form was chosen, and a risk assessment form was also completed, both were sent off and approved by Staffordshire University, they can be seen in Appendices A and B. After recording all the research, the use of participants in this study was reviewed, it was decided they were to be utilised in this study. As a result, a proportionate ethics form was filled out and sent for approval with the content the participants would be viewing and completing; this consisted of a slideshow presentation and a questionnaire, these can be seen in Appendices C, D and E and F. The proportionate ethics form was also approved by Staffordshire University.

2.1. Preliminary Research

Preliminary testing was conducted in order to decide upon how certain variables would be utilised. The first variable in this research is the three different Ring doorbells. The initial doorbell used in this research is the Ring 1st Generation Video Doorbell, next is the Ring 2nd Generation Video Doorbell and the third is the Battery Video Doorbell Plus. They all differ in various aspects, such as video quality and night vision capabilities. As the first-generation doorbell had the lowest video quality, this was the doorbell that was chosen to partake in the preliminary research, the doorbell was placed 1.46 metres high from the ground, this can be seen in Appendix G. The location decided on was a driveway that measured 10.7 metres long from the doorbell, see Appendix H. Next, two subjects were decided upon; a number plate and an individual wearing a blue hooded sweatshirt with 'GAP' wrote on the front in large white letters, both can be seen in Appendices I and J. The driveway was measured from the doorbell and set intervals were decided on. These intervals were distances ranging from 2 metres to 7 metres that would be increased by one per recording. This was important as it meant each recording could be reviewed to decide upon which distance was to be used in the final recordings. The distance of 1 metre away from the doorbell was not tested as the subjects were not visible in the footage recorded from this distance and after 7 metres, the car would not reverse any further, so this was the maximum distance chosen. Both subjects were recorded at each distance on the doorbell and the footage was stored in a secure account that is registered on the Ring application. The recordings were created via opening the Ring application on a mobile phone and pressing 'Live View'. Ring (2024) describes 'Live View' as an option that allows the user to stream what is being viewed through the doorbell straight to your device, without a subscription. From this, you can also enable sound and activate the two-way-talk function which allows the user to speak and listen to someone who may be at their door. As a subscription was active on the doorbell, this 'Live View' recording was saved to the account and was available for viewing or download.

This method for the preliminary research was chosen as it creates a standardised way of testing multiple subjects all in the same conditions. For example, as discussed in the literature review, Grgic, M, Delac K and Grgic S, in 2009, set out to create a database of human faces for the purpose of facial recognition technology. Within this

research, they recorded at various set distances in the same location on multiple surveillance cameras. Due to the success of their research and also discovering some effects directly linked to the varying distances that altered their results, this method was chosen and adapted accordingly for this research project.
During the first attempt at recording the preliminary research, it was night-time, and the weather was poor, and it was raining which ranged from light to heavy throughout the session, these can be seen in Appendix K. Upon reviewing the footage recorded in this session via the Ring website, it was determined that the rain had reduced the video quality of the footage further. Consequently, this could add potential bias when deciding which distance is to be used. As a result, it was determined the preliminary research would be recorded again when the weather improved. The same method was used the second time and the recordings were again recovered from the Ring website and reviewed, these are displayed in Appendix L.

2.2. Further Research

Following the completed preliminary research, the next step was to record the subjects at the decided upon distances on all the doorbells. After observing the recordings from the preliminary work, it was decided that the distances used would be 2, 4 and 6 metres away from the doorbell. 2, 4 and 6 metres were chosen as they were even intervals that portrayed the subjects up close, mid-range and further away from the camera without being out of shot. The same factors were to be used such as the location of recording as well as height of doorbell.

Whilst the number plate and blue hooded sweatshirt were still to be used in the research as subjects, two more clothing items were added to demonstrate a wider variety of branding and clothing styles. This included, a black sweatshirt that had a box across the chest with said ‘Just Do It’ in medium-sized white writing. As well as a white short-sleeved T-Shirt that had the writing ‘Arctic Monkeys’ wrote on the front in large but thin black font, they are showcased in Appendices M and N. The number plate on the car was placed at each distance and recorded using the ‘Live View’ function again on the Ring application on a mobile phone, this time using all three doorbells which were placed at the same point against the wall whilst recording. This

was repeated for each clothing item as the same individual wearing each piece would walk parallel to the doorbell to be recorded.

After reviewing the footage on the Ring website, it was downloaded and saved to a secure OneDrive account that is password protected.
As a result of Objective 2 being based on night-vision, it was important this research was recorded at night-time. This was chosen due to the limited research on the effects and benefits of the infrared and coloured night vision and how this applies to smart doorbells.

2.3. Enhancements in Amped FIVE

The footage was organised into folders ready to be uploaded into Amped FIVE software. The first session using Amped FIVE begun by opening the footage and selecting the frame that displayed the number plate or branding on the clothing the clearest. This was followed by accessing the ‘Filters’ section and going into ‘Group Adjust’ and then using the ‘Levels’ tool. Here the ‘Highlights’ tool was adjusted to enhance each image and brighten up the dark space in the still image. It was then saved as a screenshot and re-organised into the corresponding folders.
Despite doing it once, the method was reviewed and it was decided that changes were to be made regarding the filters used, most importantly, the method of exporting, as saving as a screenshot may have added potential compression to the image and therefore lowered the quality and created bias in the results. The images from this session can be found in Appendix E.

During the second session using Amped FIVE, the footage was once again organised into corresponding folders, broken down into each subject, distance and doorbell. Before being imported into Amped FIVE, it was decided the best way to present the footage was in still images and therefore three versions were created. They were, the unenhanced still image, the unenhanced but cropped still image and the enhanced image that also been cropped. The first tool that was used was the ‘Single Selector’ where a single frame was selected to be enhanced. Then the ‘Group Write’ tool was chosen and ‘Image Writer’ was used to format the image. The format Bitmap was chosen, and the image was saved to the secure OneDrive location. The Bitmap image

format contained uncompressed data, as a result, they can be larger than other file types but are often used to store high quality images. This is as they store each pixel independently, so the image quality is not affected, (Davis, A, 2023). This is how the footage was turned into a still image. Next, the same image was cropped to just display the car or the individual in the footage. This was then saved as a bitmap image also. Finally, the previous image was taken and was ready to be enhanced. The ‘Group Adjust’ tool was selected, followed by the ‘Levels’ tool. Under ‘Selection’, ‘Static Value’ was chosen and used to select only the number plate or the branding on the clothing item, this meant only this area would be enhanced. This decision was made to focus on how the visibility of the branding and number plate would change, whilst the colour of the subjects would be shown via the night vision settings on the doorbells. Following this, the highlight tool was adjusted to lift the levels of the image, to improve visibility. In doing so, this automatically adjusted the mid tone level also. The ‘Image Writer’ tool was then used again to save the image as a bitmap file. The images can be seen in Appendix F.

2.4. Research Design

The research design chosen was a questionnaire. This was chosen as it would allow for the collection of personal opinions in an efficient and controlled way. Before the second session with Amped FIVE, data was collected from the first participant group. A slideshow presentation was put together that compared the unenhanced and enhanced version of each image side-by-side for each subject, distance, and doorbell. Google Forms was used to create the questionnaire, this is due to the user-friendly interface, and it also allows participants to quickly log-in with their university email without having to create an account beforehand to participate. The first participant group were sourced via the project supervisor who allocated time before a lecture for participation in the study. The group consisted of Level 4 Staffordshire University students who were briefed about this research project and were asked to participate and told that it would be anonymous. They were provided with a link to the questionnaire which they were to complete based on the images in the slideshow which was made available to them to download and view, via Blackboard; a website used by the university to share learning materials and information regarding courses to students.

Throughout the slideshow presentation, the images were split into two parts, one being those that contained the number plate whilst the other contained the clothing items. Each part was then further separated into sections, with each section consisting of the images taken from one doorbell. The sections each contained three slides, each slide represented a different distance creating a total of 36 slides. The questionnaire began by asking them to rate their eyesight based on a linear scale that ranged from 1 being the best and having no correction needed, to 5 being the worst with very poor eyesight. The questions based on Part One, stated which slide they should refer to and focused on asking questions such as:

- What colour do you think the car is?
- What image is easier to read from?
- Write down any letters or numbers you can read from the number plate.

The questions in Part Two included:

- What colour is the T-Shirt the person is wearing in this image?
- Can you identify anything about any branding on the T-Shirt?
- What colour are the trousers the person in this image is wearing?
- Which image is easier to identify from?

Short-answer question format was chosen as by allowing the participant to write their own answer, they are not faced with pre-written answers that might sway their own opinion, therefore, preventing bias within their answers.

Feedback was received from this participant group and when combined with improvements made to the images from the second session in Amped FIVE, it was decided the questionnaire and slideshow would be edited to include these changes and presented to another group of participants. Changes to the slideshow presentation included, using three images instead of two: the first being the unenhanced, uncropped version, the other being the unenhanced but cropped image and finally, the enhanced image. This was done for each slide and the numbering of the slides was altered to make it clearer to the participant. Additionally, for the question of which image is easier to read from, rather than the options being left or right, they were

changed to image 1,2,3 or none of the above. Finally, following the question surrounding the participants eyesight, they are asked about which device they are using to view the slideshow presentation and how they are viewing it with the options being either full screen, split screen or switching between tabs. They were also instructed to not discuss answers with others and view the presentation at full screen if possible. The second participant group were also sourced via the project supervisor and were Level 5 students at Staffordshire University.

2.5. Ethical Considerations

Before collecting research. two ethics forms were completed and approved by Staffordshire University. All participants were fully informed about the research prior to taking part and were provided with an information sheet and the option to ask any questions they may have. The questionnaire was voluntary and completely anonymous with no personal information being recorded. Additionally, they were provided with the right to withdrawal until point of submission of answers and were again, fully informed of this. All participants completed a consent form before completing the questionnaire that stated all the above. The research contained no harmful content to the participants and was confidential as answers cannot be linked to an individual participant.

2.6. Data Analysis

To analyse the data collected, an Excel spreadsheet was created that displays all the raw data from each participant. The data from each participant group was kept separate but both were chosen to be analysed. Participant Group 1 refers to 45 participants that partook in the first session, whilst, Participant Group 2, refers to 25 participants that answered the questionnaire in the second session. By analysing the groups separately, if bias was present caused by the wrong exporting method in Group 1, it could be identified. Multiple sheets were then created that corresponded to the questions asked.

The data was mostly put into tables that correlated to the data from each doorbell and tallied. However, for questions asking to identify branding, letters or numbers, raw results were presented in a table.

Results and Discussion

There are three sections of results, each section focuses on a question asked to the participants about the images which aligns with the research objectives. The raw data from each participant groups can be found by following the link in Appendix O

3.1. Colour of the Subject

This section will discuss both Objective 1 and 2, The first subject focused on is the car, which can be viewed in Appendix I. The First-Generation doorbell images can be seen in Slide 1-3, Second-Generation doorbell images can be seen in Slides 4-6 and Video Doorbell plus images in 7-9, all in Appendices E and F.

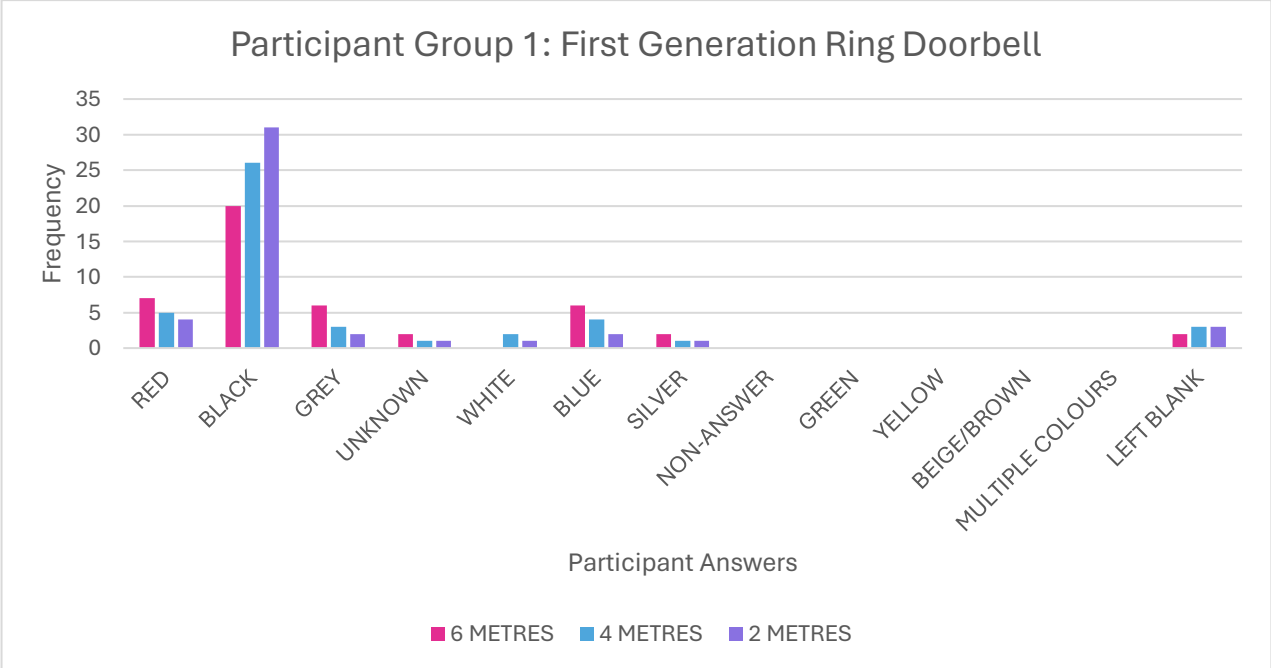

Figure 1: Participant Group 1's Responses to the Question, "What Colour Do You Think The Car Is?" Based on Images Captured via the First-Generation Ring Doorbell

Figure 1 shows results obtained from Participant Group 1. The images can be seen in Slides 1-3 in Appendix E. 'Non-answer' refers to an answer given that is unrelated to the question, whilst 'Unknown' is when they have stated they are unsure. This version of the questionnaire also allowed participants to leave a question unanswered and therefore that data is represented by the 'Left Blank' category. When participants provided more than one answer, only their first was recorded. At all three distances, the most common answer was 'Black'.

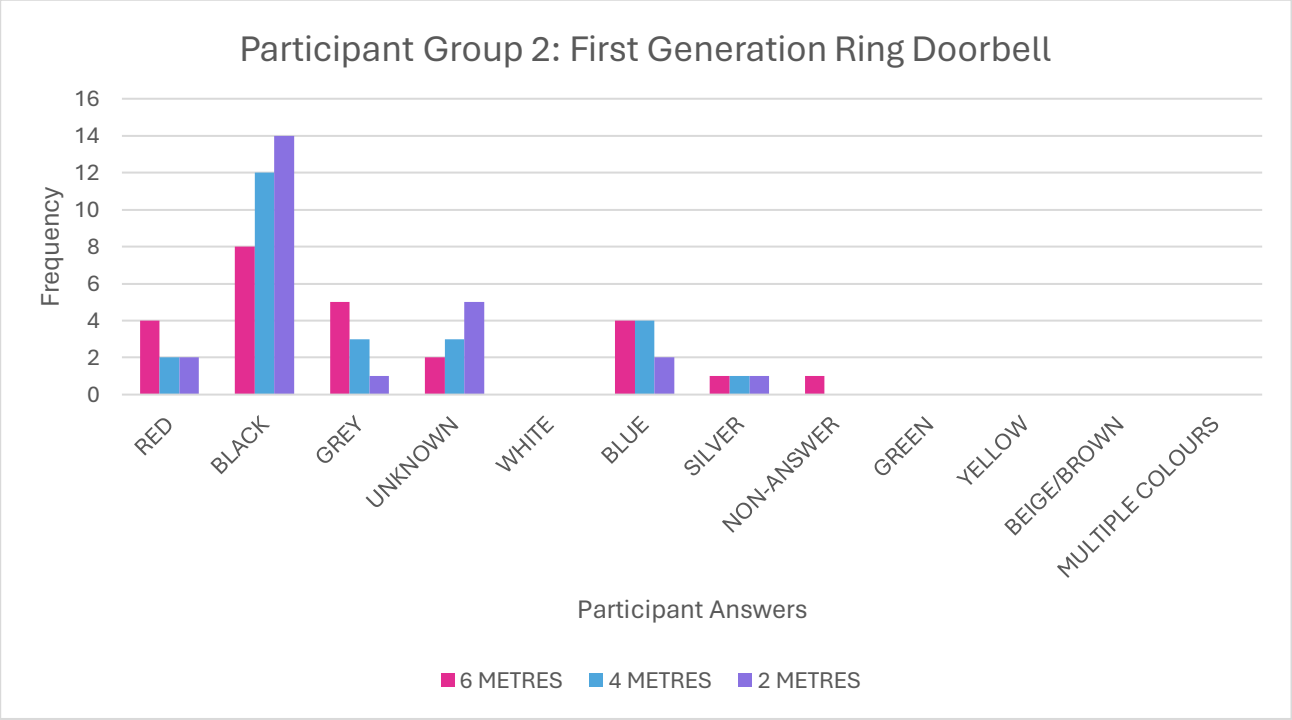

Figure 2: Participant Group 2's Responses to the Question, "What Colour Do You Think The Car Is?" Based on Images Captured via the First-Generation Ring Doorbell

Figure 2 showcases the data recorded for the same question but asked to Participant Group 2. In this version, the questions were required and therefore participants had to provide an answer so there is no 'Left Blank' category. At all distances, the most common answer was that the car was also 'Black'.

Despite the differences in images that were displayed between Group 1 and Group 2, both groups most common answer was the same. The visibility of the car increases as the subject is placed further away from the camera; this may be due to being closer to the streetlamp that was on throughout the research. On the other hand, the results show that the distance does not change the ability to correctly state the colour of the

car as most participants guessed the same regardless of distance. Despite some participants correctly guessing ‘Red’, the infrared night vision displays the footage in greyscale and therefore the participants cannot state the colour without it being an estimation. Overall, the low video quality of the First-Generation doorbell led to an inability to identify the colour of the car.

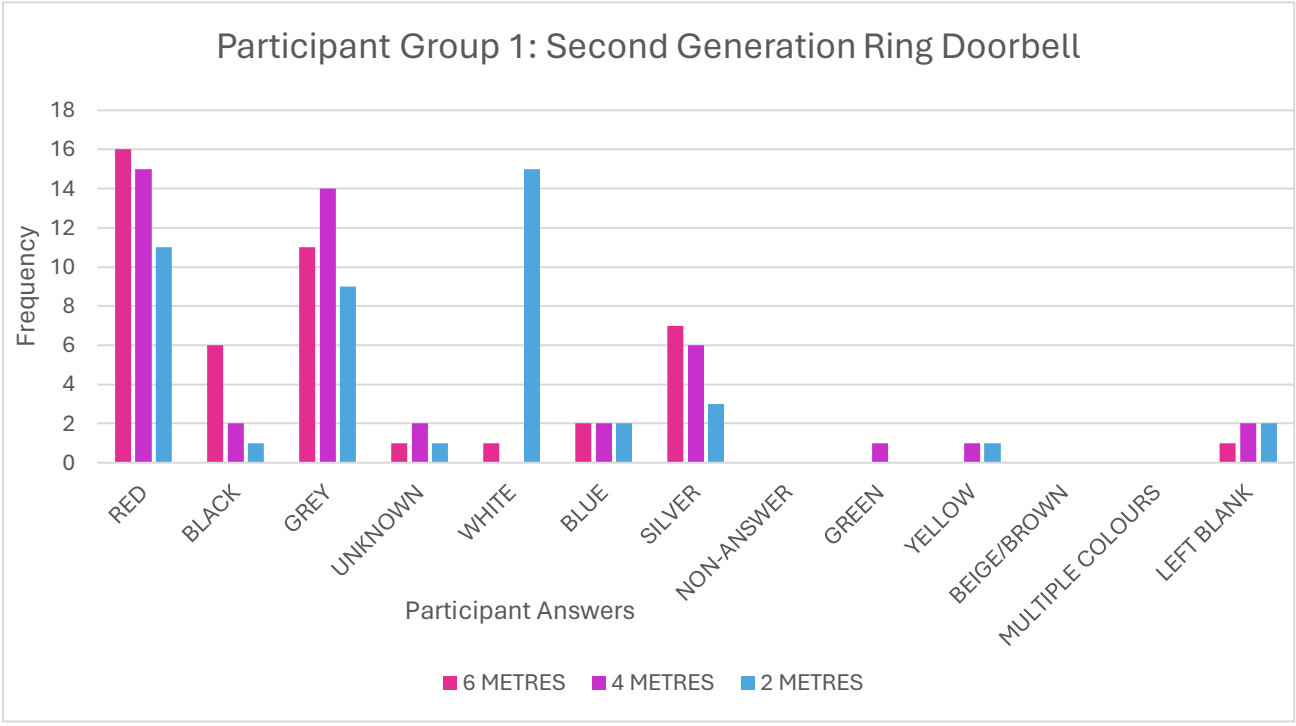

Figure 3: Participant Group 1’s Responses to the Question, “What Colour Do You Think The Car Is?” Based on Images Captured via the Second-Generation Ring Doorbell

Figure 3 represents the participant answers from the Second-Generation Doorbell. For 6 and 4 metres, the most guessed answer was ‘Red’, whilst for 2 metres, it was ‘White’. The second most popular for 2 metres was ‘Red’ whilst for 6 and 4 metres, it was ‘Grey’.

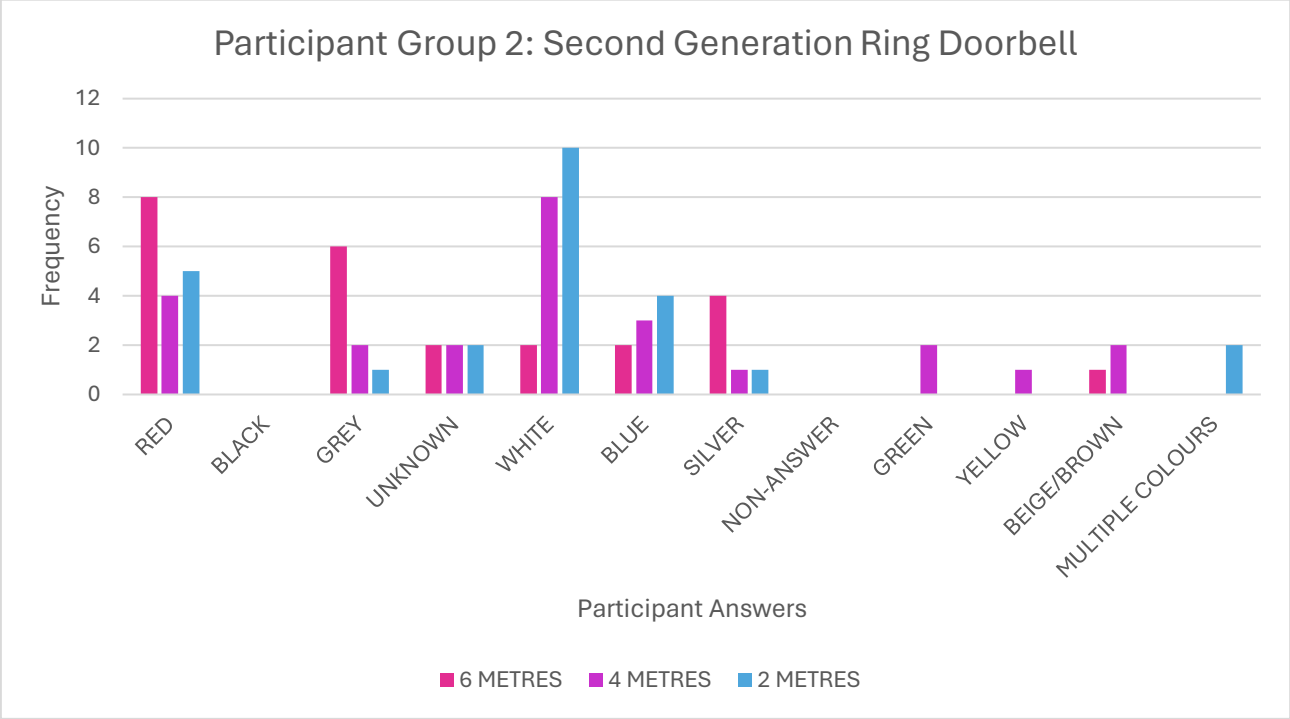

Figure 4: Participant Group 2's Responses to the Question, "What Colour Do You Think The Car Is?" Based on Images Captured via the Second-Generation Ring Doorbell

Figure 4 demonstrates that, for 2 and 4 metres, the most common answer was 'White' whilst, for 6 metres it was 'Red'. Whilst those that guessed 'Red' would be correct, there is no colour information displayed in the footage generated by the Second-Generation Ring Doorbell due to the infrared night vision, as previously discussed. The camera reflects the car as it gets closer leading to it appearing a lighter colour, especially in the enhanced versions. This could explain why participants chose 'White' as their answer for 2 and 4 metres and chose a darker shade such as 'Red' for further away. The improved video quality of this camera means less people answered 'Unknown' than for First-Generation images but still faced the issue with the infrared night vision.

Table 1: Participant Group 1 and 2's Responses to the Question, "What Colour Do You Think The Car Is?" Based on Images Captured via the Ring Video Doorbell Plus

	6 METRES	4 METRES	2 METRES
RED	69	69	68
BLACK	0	0	0
GREY	0	0	0
UNKNOWN	1	1	0
WHITE	0	0	0
BLUE	0	0	0
SILVER	0	0	0
NON-ANSWER	0	0	1
GREEN	0	0	0
YELLOW	0	0	0
BEIGE/BROWN	0	0	0
MULTIPLE COLOURS	0	0	0
LEFT BLANK	0	0	1

Table 1 demonstrates Participant Group 1 and Group 2's results combined into one visual as answers were so similar. The images for this question can be found in Slides 7, 8 and 9 of Appendices E and F. The most common answer for both groups and all distances was 'Red'. With only 2 answers for 'Unknown', one person leaving it blank and another giving an unrelated answer. Even with the car being far away at 6 metres compared to 2 metres, most participants could correctly identify the colour of the car due to the coloured night vision that is present in the Ring Video Doorbell Plus.

The Video Doorbell Plus was identified to be the most beneficial camera for identifying the colour of the car due to the coloured night vision that it offers as opposed to the infrared night vision used with the First and Second-Generation Doorbells. The answers based on the Second-Generation also contained correct answers, but this cannot be concluded upon whether it was identified or guessed due to the lack of colour information. The First-Generation gave the most incorrect answers with most participants guessing 'Black' due to the poor quality of the camera and the car being almost indistinguishable at 2 and 4 metres. In this case, the further distance improved the visibility due to not reflecting and more lighting, however this may be due to the

street lighting which could not be controlled and is therefore a research limitation. Distance did not affect the visibility of the subject when the video quality was high and the night vision was in colour but did affect the First and Second generation as at 2 metres, the car appeared lighter in colour which promoted answers of the car being white.

The next subject to be focused on is the T-Shirt, which can be seen in Appendix N. The First-Generation doorbell images can be seen in Slide 10-12, Second-Generation doorbell images can be seen in Slides 13-15 and Video Doorbell plus images in 16-18, all in Appendices E and F.

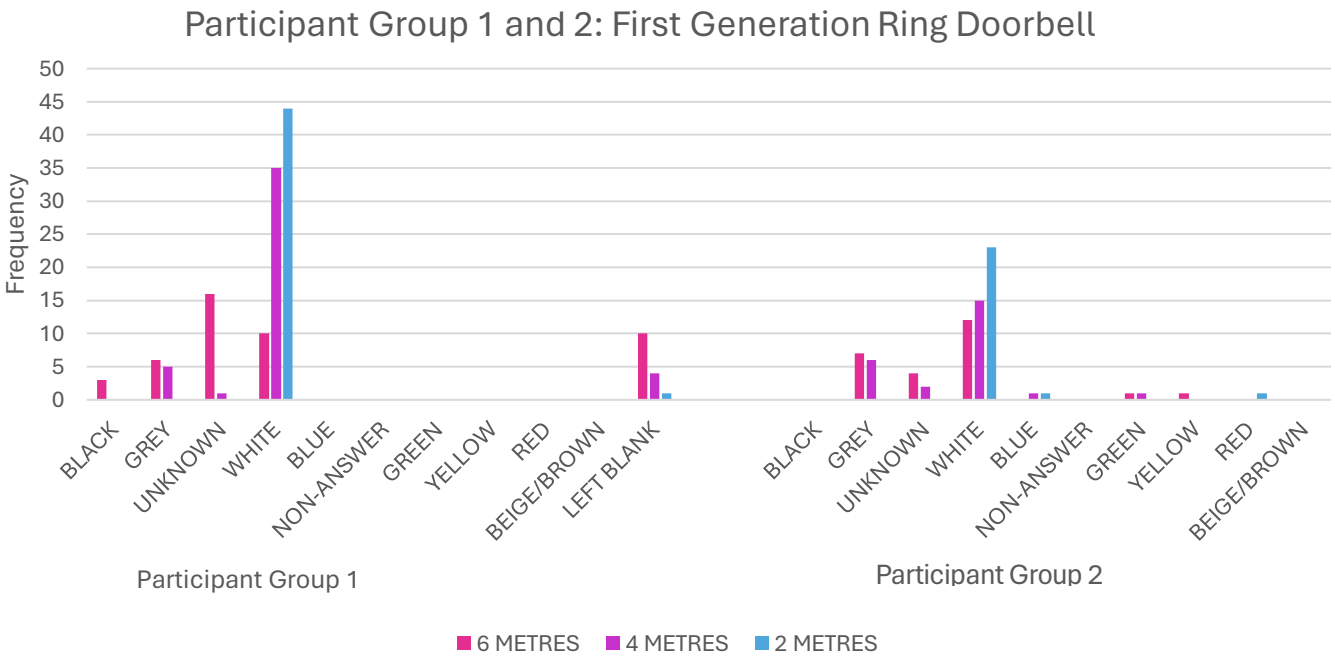

Figure 5: Participant Group 1 and 2's Responses to the Question, "What Colour Do You Think The T-Shirt Is?" Based on Images Captured via the First-Generation Ring Doorbell

Figure 5 displays the participant answers for both Group 1 and 2 for the First-Generation Ring Doorbell. The most common answer in both groups for 2 and 4 metres was 'White' whilst for Group 1, the most common for 6 metres was 'Unknown' and for Group 2, it was also, 'White'. Despite the camera being low video quality, the colour of the T-Shirt was correctly identified by those that said 'White'. As the individual wearing the T-Shirt got further away from the camera, the amount that answered

'White' decreased, however, the second most common answers for 6 metres was either 'Grey', 'Unknown' or it had been left blank. Despite, the infrared night vision only being greyscale, the participants could still correctly identify the colour of the T-Shirt, however, could be attributed to white being a shade and not a colour and therefore it is still visible without coloured night vision. Moreover, the white allows reflection to happen and makes the T-Shirt stand out even when at 6 metres away from the camera. These findings demonstrate distance does affect the visibility as correct answers increased at 2 metres rather than 6 metres, but it was not the only contributing factor to the improved visibility of this subject.

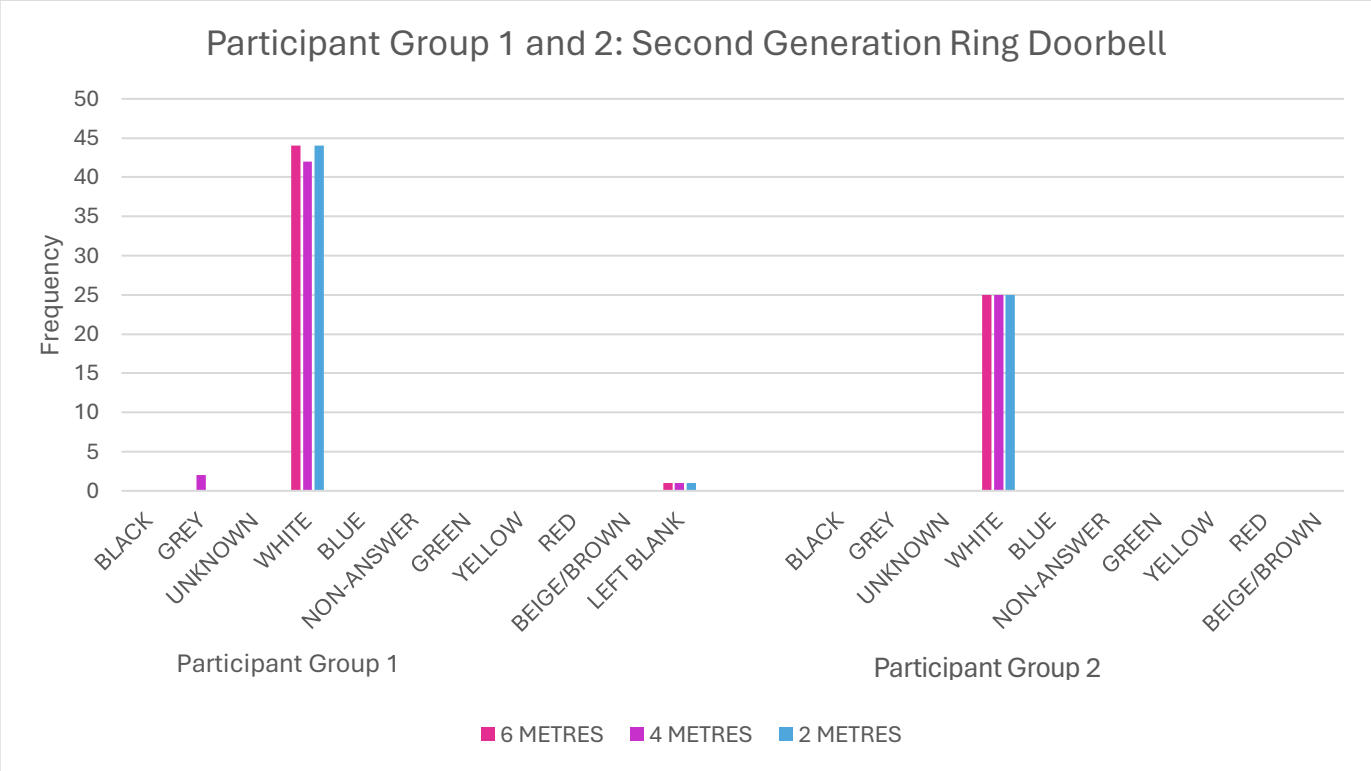

Figure 6: Participant Group 1 and 2's Responses to the Question, "What Colour Do You Think The T-Shirt Is?" Based on Images Captured via the Second-Generation Ring Doorbell

Figure 9 displays results for the Second-Generation Ring Doorbell, images for this question can be found in Slides 13, 14 and 15 in Appendices E and F. In both participant groups, the most common answer was 'White' at all three distances. With only two participants answering 'Grey' and 1 count of the answer being left blank for both 4 and 2 metres. The reason for 'White' being the most common answer is the same as discussed for Figure 8. The improved video quality of the Second-Generation also may have led to an increase in confidence that the T-Shirt was in fact white and

therefore created a decrease in participants answering other colours, answering ‘Unknown’ or leaving it blank.

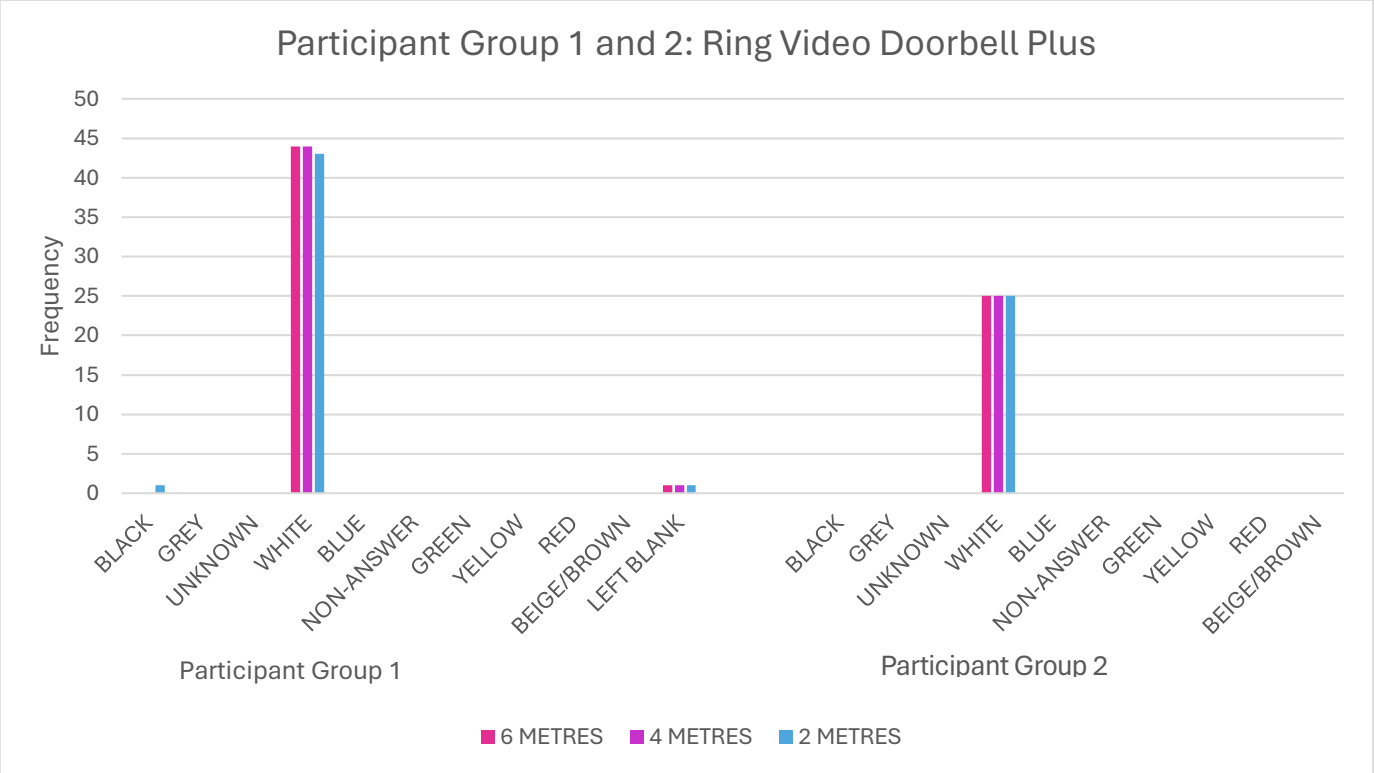

Figure 7: Participant Group 1 and 2’s Responses to the Question, “What Colour Do You Think The T-Shirt Is?” Based on Images Captured via the Ring Video Doorbell Plus

Figure 7 displays the results for the Ring Video Doorbell Plus. Much like the Second-Generation doorbell, the most common answer across all distances and both participant groups was ‘White’. This is again for the same reasons as discussed previously. The colour night vision may have further increased the participant’s confidence that the T-Shirt was white as only one participant left the answer blank for all distances in Group 1 and one answered “Black’. However, that individual participant answered, “Black and White”, but due to only first answers being recorded, the white was not tallied. Therefore, it can be assumed that they were referring to the white T-Shirt and black sleeves that the individual is wearing.

Overall, the images recorded from the Ring Video Doorbell Plus provided the most correct answers regarding the colour of the T-Shirt. Despite this, the Second-Generation doorbell also provided a high number of correct answers and therefore it cannot be attributed to the change in night vision that allowed the participants to identify the colour. Additionally, distance only made a difference in answers with the

First-Generation doorbell, as the number of correct answers increased the closer the individual was to the camera; because of this, it can be assumed that the poor video quality of the doorbell, that got worse as distance increased, was the issue and not the night vision affecting the visibility. It can also be mentioned that the street lighting that is present in all images does not seem to have an effect at improving the visibility at 6 metres due to the subject being smaller in size compared to the car.

The next subject focused on is the Blue Hooded Sweatshirt that can be seen in Appendix J. The First-Generation doorbell images can be seen in Slide 19-21, Second-Generation doorbell images can be seen in Slides 22-24 and Video Doorbell plus images in 25-27, all in Appendices E and F.

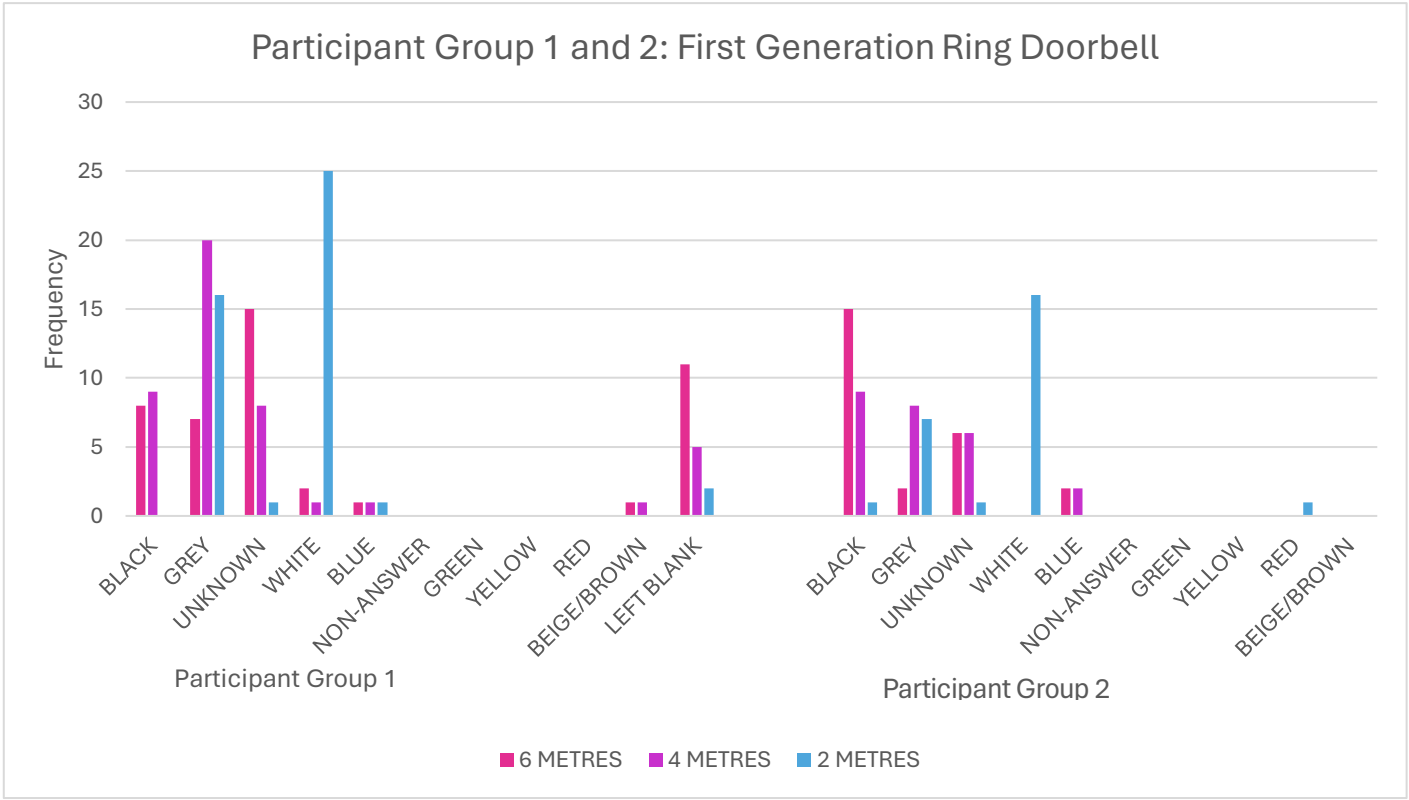

Figure 8: Participant Group 1 and 2's Responses to the Question, "What Colour Do You Think The Sweatshirt Is?" Based on Images Captured via the First-Generation Ring Doorbell

Figure 8 represents the answers for both participant groups when asked about the Blue Hooded Sweatshirt. For 2 metres, the most common answer in both participant groups was 'White'. As discussed before, when in close distance with the camera, the subject seems to reflect and therefore creates the illusion that the subject is a lighter

colour than it really is, this explains the high number of answers saying ‘White’ and the second most common being ‘Grey’. This also is in favour of the assumption that the infrared night vision was negatively affecting the visibility of the subjects as the image is only displayed in greyscale. Moreover, for 4 metres, the most common answer was ‘Grey’ for Group 1 and ‘Black’ for Group 2. As the distance away from the camera increases, the visibility of the individual is very minimal, this may be attributed to the poor video quality of the camera, as the distance increases, the quality gets worse. Finally, at 6 metres, the most common answer was ‘Unknown’ for Group 1 and ‘Black’ for Group 2. The previous explanation also applies to these answers. Furthermore, as the distance increases again, the visibility becomes worse and the individual wearing the sweatshirt is barely visible, this explains the high number of participants answering with ‘Unknown’.

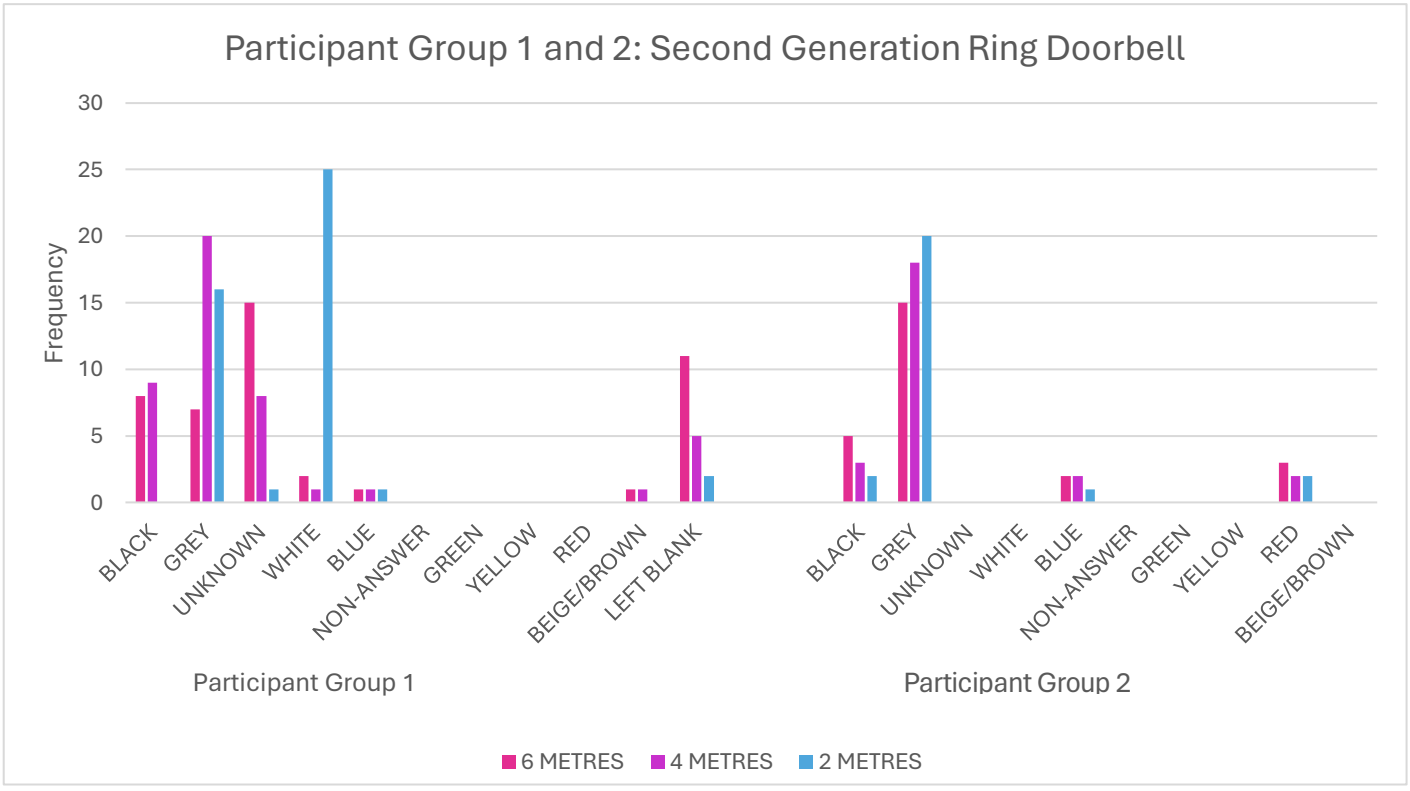

Figure 9: Participant Group 1 and 2’s Responses to the Question, “What Colour Do You Think The Sweatshirt Is?” Based on Images Captured via the Second-Generation Ring Doorbell

Figure 9 represents the answers provided from both groups about the Second-Generation Ring Doorbell. At 2 metres, the most common answer from Participant Group 1 is that the sweatshirt was ‘White’; at 4 metres, they most frequently chose

‘Grey and at 2 metres, ‘Unknown’. Meanwhile, at all distances, Participant Group 2’s most common answer was ‘Grey’. Due to this sweatshirt being blue and not a shade that would appear with the infrared night vision better as seen above, it is harder to distinguish what colour the sweatshirt is. Only 8 out of 70 participants correctly answered ‘Blue’, but this can only be assumed to be a guess due to these factors. Participants often choose the colours that are a part of the greyscale when asked for the First and Second Generation rather than assuming that the colour has not been picked up by the camera, this is supported in these results.

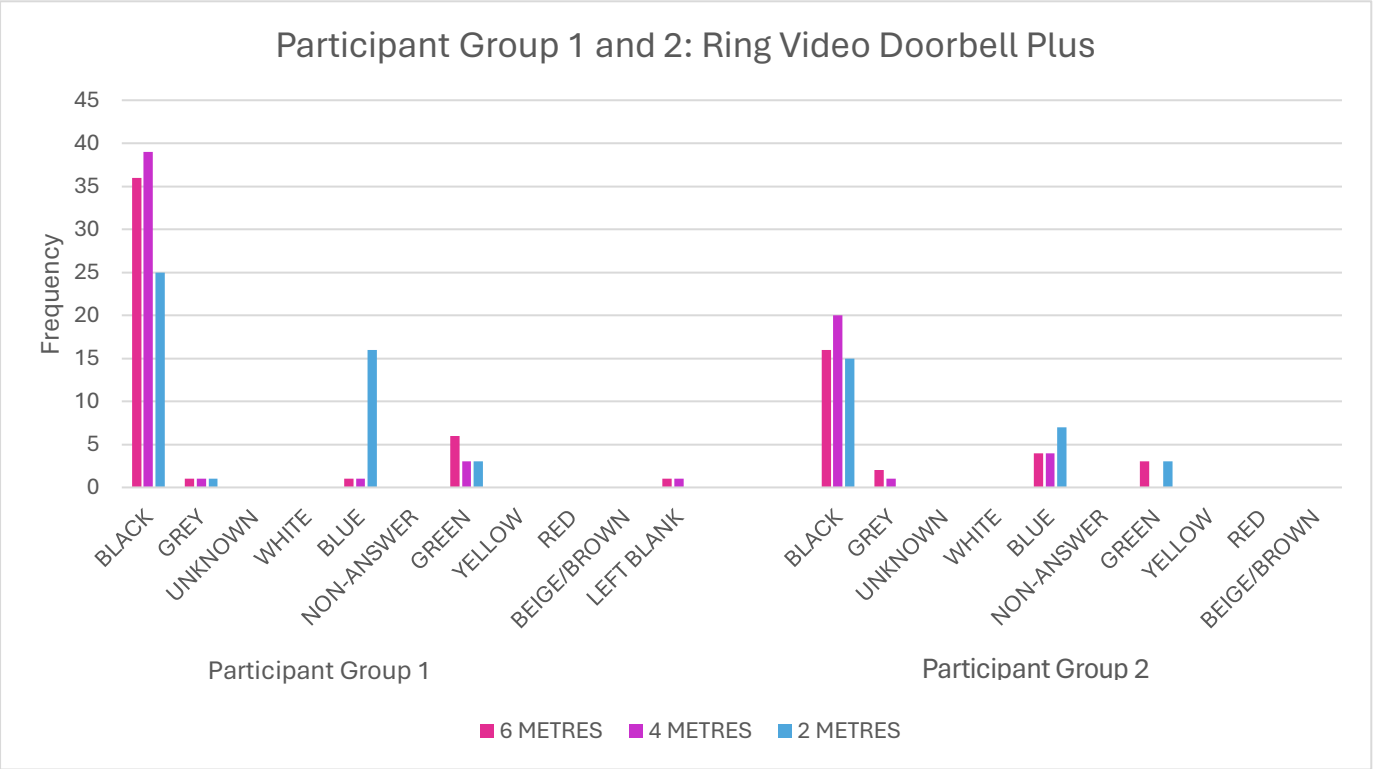

Figure 10: Participant Group 1 and 2’s Responses to the Question, “What Colour Do You Think The Sweatshirt Is?” Based on Images Captured via the Ring Video Doorbell Plus

Figure 10 displays the questionnaire answers for the images from the Ring Video Doorbell Plus. The most common answer for all distances across both participant groups was ‘Black’. Additionally, at 2 metres, the second most common for both groups was ‘Blue’. Despite having the coloured night vision, the majority of the participants did answer incorrectly. However, when viewing the images, at 6 and 4 metres, the sweatshirt can be seen to be a dark colour but does not clearly appear blue. Whilst at 2 metres, the individual can be seen stopping in an area that is better lit, this is a research limitation as light from the house may have illuminated the sweatshirt and

therefore allowed the participant to view the subject in better lighting to be able to identify the sweatshirt as blue. If this was the case however, it did not change opinions enough to alter the most frequent answer between distances.

Overall, the number of participants answering correctly did increase from the First and Second Generation to Video Doorbell Plus, therefore, the results further support that the colour night vision improved the participants ability to correct identify the colour of the subject as opposed to the infrared night vision. On the other hand, for the Video Doorbell Plus, the smaller the distance between the subject and doorbell, the more participants answering correctly due to the image becoming clearer; meaning an increase in visibility of the subject overall.

This next section will focus on the Black Sweatshirt, which can be seen in Appendix M. The First-Generation doorbell images can be seen in Slide 28-30, Second-Generation doorbell images can be seen in Slides 31-33 and Video Doorbell plus images in 34-36, all in Appendices E and F.

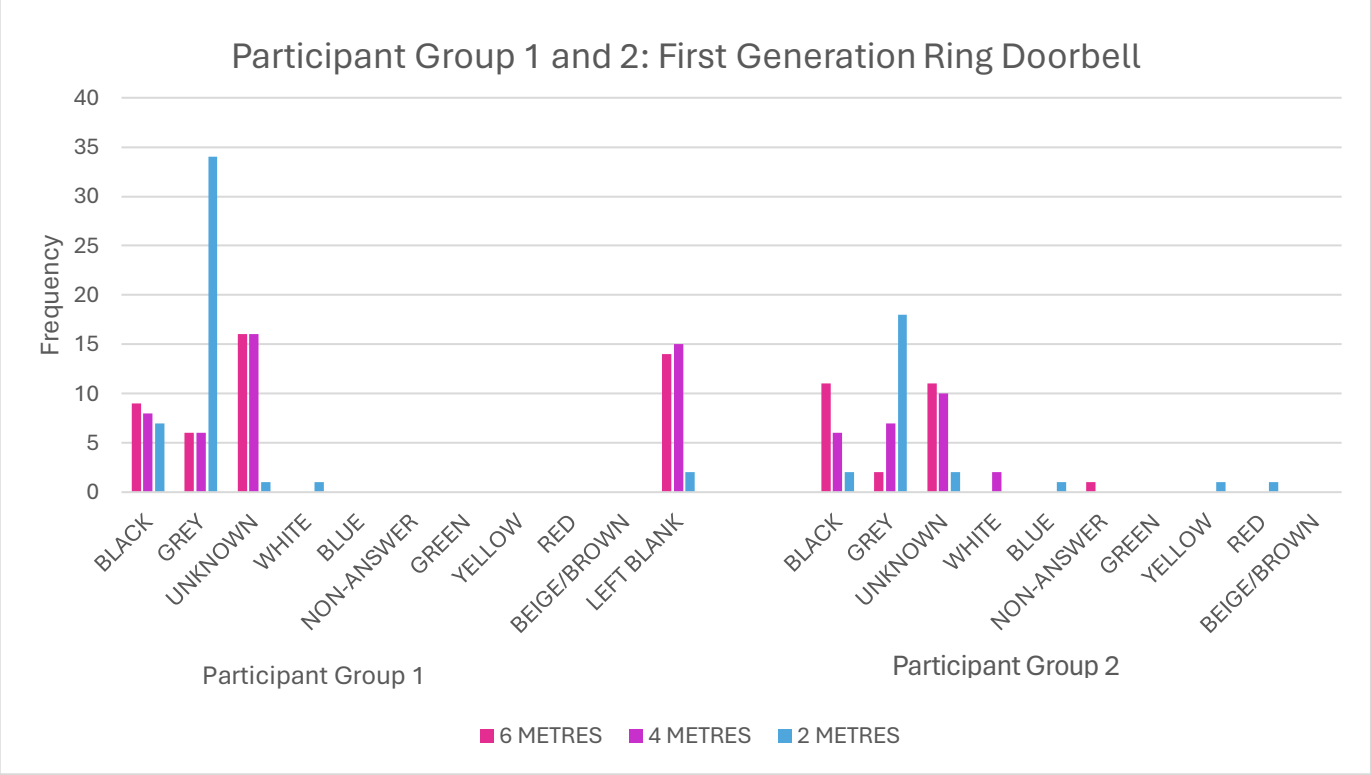

Figure 11: Participant Group 1 and 2's Responses to the Question, "What Colour Do You Think The Sweatshirt Is?" Based on Images Captured via the First-Generation Ring Doorbell

Figure 20, as seen above displays Participant Group 1 and 2 and the results for the question based on the First-Generation Doorbell and the Black Sweatshirt. The most common answer for both groups at 2 metres was ‘Grey’. In Group 1, the most frequent answer for 4 and 6 metres was ‘Unknown’. Meanwhile, for Group 2, at 6 metres, they chose ‘Black’ and ‘Unknown’ for 4 metres. In the images, at 6 metres, the individual wearing the sweatshirt is nearly undistinguishable, this explains as to why the majority opted for ‘Unknown’ or even left the answer blank. Additionally, it also explains why the participants chose ‘Black’ as despite this being the correct answer, the subject blurs into the background. This is the same for at 4 metres and explains why the majority chose ‘Unknown’. At 2 metres, the subject comes into focus but due to the greyscale from the infrared night vision, the black sweatshirt only appears to be a dark grey, as a result, this was the most common answer. In these images, distance greatly affected the visibility with the subject only being visible once at 2 metres away from the camera. Furthermore, the infrared night vision causes a hinderance to the participants ability to correctly identify the colour of the sweatshirt.

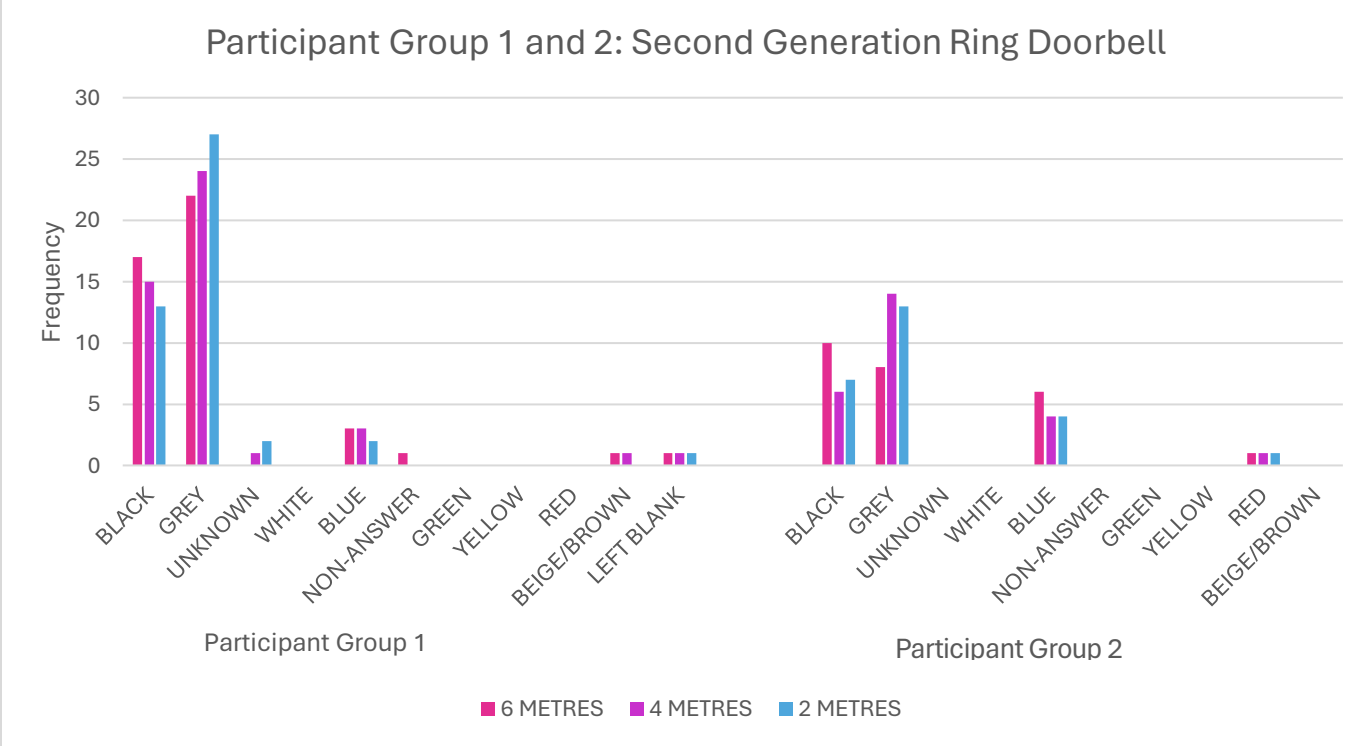

Figure 12: Participant Group 1 and 2’s Responses to the Question, “What Colour Do You Think The Sweatshirt Is?” Based on Images Captured via the Second-Generation Ring Doorbell

Figure 12 discusses the Second-Generation Doorbell. In Participant Group 1, the most common answer across all distances was that the sweatshirt is ‘Grey’. Whilst this was also the most common answer for Group 2 at 2 and 4 metres. At 6 metres, participants most frequently guessed ‘Black’. The reasoning for this is the same as seen above. Whilst the image quality improves with this doorbell, the infrared night vision still displays the black sweatshirt as grey. However, at 6 metres, the subject does appear a darker shade of grey, resulting in the most common answer at this distance for Group 2 being, ‘Black’. Much like the T-Shirt, black is not a colour and is therefore a shade so can be recognised easier on the First and Second-Generation doorbells compared to the Blue Hooded sweatshirt as it produces the footage in greyscale. This explains why some were able to identify the colour of the sweatshirt, however, this does not continue as when the distance between the subject and the camera decreases, the lighter the sweatshirt appears. This means that distance negatively affected the visibility of the sweatshirt, on the basis that those who said that the sweatshirt was black was because they correctly identified it and were not guessing, however, this can not be specified.

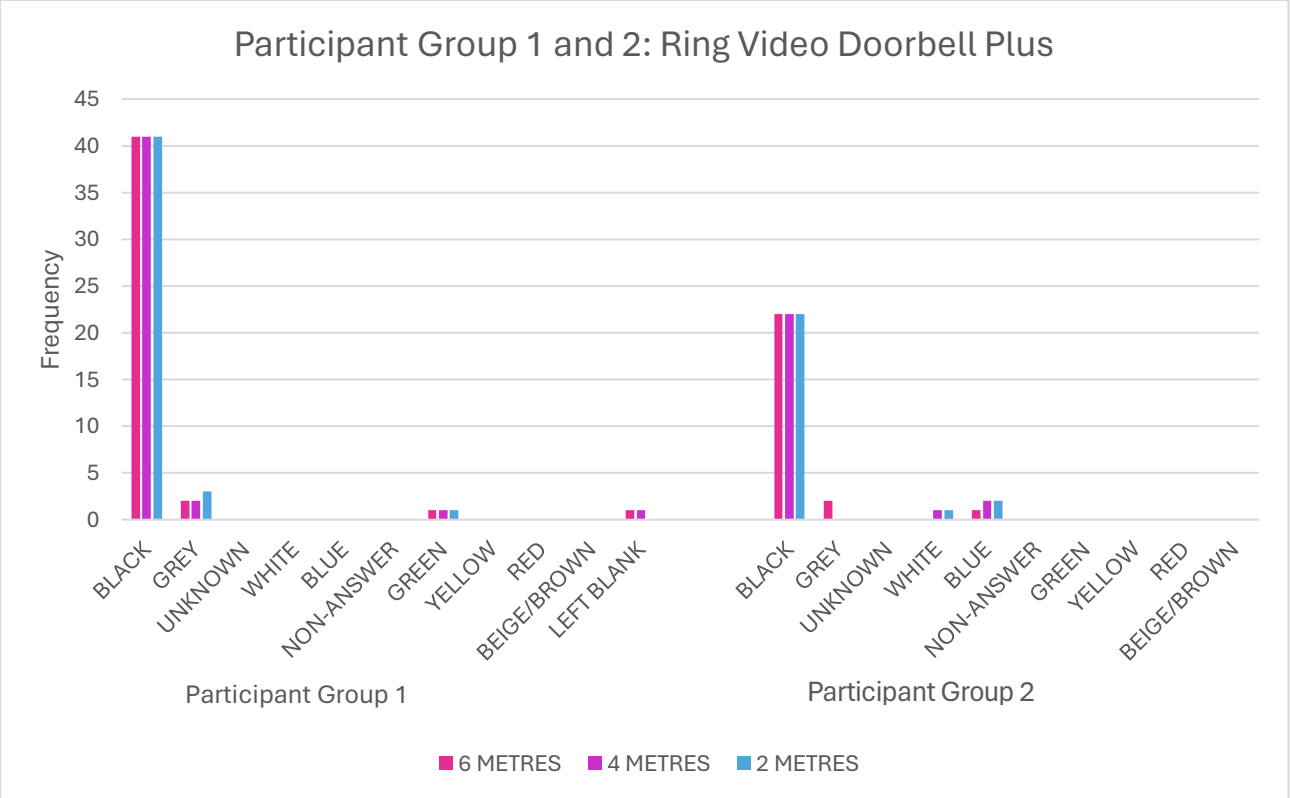

Figure 13: Participant Group 1 and 2’s Responses to the Question, “What Colour Do You Think The Sweatshirt Is?” Based on Images Captured via the Ring Video Doorbell Plus

Figure 13 displays that for both groups and across all distances, the participants correctly identified the sweatshirt as being ‘Black’ most commonly. Whilst some correctly identified the sweatshirt colour in the Second-Generation Doorbell images, the use of coloured night vision significantly improved the number of correct answers due to displaying the images in colour and confirming without ambiguity that it is black and therefore showcasing how the colour night vision can improve the visibility of the subject. Furthermore, the Video Doorbell Plus saw a decrease in participants answering ‘Unknown’ or leaving the entry blank compared the First-Generation Doorbell; this is more data that supports the conclusion that coloured night vision improves confidence in confirming the colour of the subject. In this instance, distance did not make a difference as participants correctly identified the colour at 2, 4 and 6 metres.

Overall, the Video Doorbell Plus again allowed participants to correctly identify the colour of the sweatshirt. Whilst some participants identified the sweatshirt as black with the Second-Generation as it is visible due to being a shade with the infrared night vision. The overall frequency of the answers ‘Unknown’ and those left blank decreased with the Video Doorbell Plus. This can be again, attributed to the colour night-vision improving the visibility of the subject. The distance did not affect the number of correct answered received for the Video Doorbell Plus and Second-Generation as the majority provided the same answers for both in Group 1 and 2, but this may be due to the upgraded video quality in these cameras. However, the poor video quality of the First Generation meant at 6 and 4 metres, the subject could not be seen and only at 2 metres was it visible, this provides countering arguments as to whether distance affects the visibility or whether it is down to the video quality of the individual doorbells.

To conclude, the colour of the subject was correctly observed the most from the images produced by the Ring Video Doorbell Plus. It can be concluded that the coloured night vision significantly improves the visibility of the colour of each subject as opposed to the infrared night vision camera. An exception to this was the white T-Shirt which was clearly visible in the Second-Generation doorbell images however, this is due to the white being a shade rather than a colour and therefore it is still visible in the greyscale images that are produced by this doorbell. Whilst the black sweatshirt is also a shade, it appeared grey in colour on the images, this can be explained by identifying that

infrared cameras use heat to capture information and turn it into visuals, as a result, the person wearing the sweatshirt was naturally producing heat, called thermal radiation, (Shuk-Ming. L, 2010). This was picked up by the camera and made the sweatshirt appear lighter in colour. This was however remedied by the coloured night vision on the Video Doorbell Plus. The video quality of the First-Generation Doorbell was a contributing factor to the lack of correct answers in the questionnaire, as often the subjects were blurred and could not be identified. On average, for the clothes, the closer the subject was to the camera, the easier it was to identify the colour. Despite this, the closer the car was to the camera, it made it more difficult due to the infrared cameras making the car appear lighter in colour than it was. Again, this could be remedied by using the Video Doorbell Plus instead.

3.2. Visibility Of Letters, Numbers and Branding

For this section, the results will focus on the question asking about the visibility of the letters and numbers of the number plate as well as the branding on each three clothing subjects. This will mainly aim to address Objective 1. The first subject focused on will be the number plate from the car. A photo of the number plate can be seen in Appendix I. The First-Generation doorbell images can be seen in Slide 1-3, Second-Generation doorbell images can be seen in Slides 4-6 and Video Doorbell plus images in 7-9, all in Appendices E and F. All participant answers for each question in this section can be found by accessing the link in Appendix P.

Beginning with the First-Generation doorbell images, no participants from either group could identify any letters or numbers from the number plate. Some in Group 1 decided to leave the answer blank which can be assumed that they cannot identify anything. After viewing the images, it is clear that the issue is the number plate reflecting. At 4 metres, this was the same as above; out of 70 participants only 1 participant tried and successfully identified the ‘1’ as well as saying there was a ‘0’ there also, this may have been confused with the ‘O’. At 2 metres, visibility improved and 24 identified the ‘W’, 39 said the ‘O’ or ‘0’, 17 for the ‘1’ and 6 for the ‘6’. Whilst in Group 2, two participants were able to identify the correctly identify, ‘WO16’. This demonstrates an improvement in visibility just from distance alone, and at 2 metres, the issue of

reflection was not as prominent allowing for some identification to take place from the participants.

For the Second-Generation Doorbell, out of all participants across both groups and the three distances, not one could identify any letter or number present on the number plate. When looking at the images, it is clear the number plate has been reflected and meant that no part could be identified, regardless of distance.

Furthermore, for the Video Doorbell Plus, at 6 metres, there were some identifications of the beginning letters like for the First-Generation with 17 saying ‘W’, 9 saying ‘O’, 6 saying ‘1’ and 6 identifying ‘6’. One participant identified ‘WO16’ with another answering, ‘O16GEU’; only one participant correctly identified the whole number plate. At 4 metres, this increased to 22 participants across both groups correctly identifying the whole number plate. A common mix up was thinking the ‘G’ was a ‘C’. At 2 metres, 56 participants out of the 70 correctly identified the full number plate but only one being able to identify nothing an another leaving it blank.

To summarise, when the issue of reflection does not occur, a smaller distance between the subject and the camera means the visibility improves and the number of participants able to correctly identify the full number plate increases. Despite this, the Video Doorbell was the only camera that did not have an issue with the reflection of the number plate enough to hinder the ability to identify the letters or numbers. This may be attributed to the coloured night vision of the camera however it is unable to be concluded upon with these results.

The next subject is the White T-Shirt, a photograph of this can be found in Appendix N. The First-Generation doorbell images can be seen in Slide 10-12, Second-Generation doorbell images can be seen in Slides 13-15 and Video Doorbell plus images in 16-18, all in Appendices E and F.

For the First-Generation Doorbell, at 6 metres, no one out of the 70 participants across both groups could identify any branding from the T-Shirt. This is the same for at 4 metres, although some decided to guess with one person saying, ‘Adidas’ and others pointing out that there are words on the chest area. At 2 metres, there were similar

guesses at to what it could be, but the majority of participants said they could not identify anything. As the subject gets closer to the camera, it is still barely visible that there is any type of branding at all present on the T-Shirt. This demonstrates that the small distance does improve visibility but cannot be relied upon to allow a clear image to be produced. The poor video quality of this doorbell additionally adds blur to the image meaning the logo would not be visible unless the quality significantly increased.

For the Second-Generation doorbell, at 6 metres, 69 out of 70 participants said they were unable to identify anything whilst one participant commented, that there was ‘graphics on the chest area’. At 4 metres, across both participant groups’ most still could not identify any branding. Whilst others answered, ‘north face’. ‘adidas’, and ‘black writing across the chest’. There are more answers, but they focus on the fact there is something visible on the chest, but it cannot be identified. Meanwhile, at 2 metres, the results are very similar with some brands that are incorrect or stating there is a ‘box on the chest area’. The decrease in distance between the subject and camera allowed more participants to guess as to what the branding was but however, no one correctly identified it.

Finally, for the Video Doorbell Plus, at 2 metres, most participants still could not identify any branding present on the white T-Shirt. Some suggested there was a ‘dark area across the chest’ but it was still unclear. These results were consistent throughout with answers on images from 4 and 2 metres also produced like results. None of the branding could be identified.

Overall, across all three doorbells, and distances, not one participant could correctly identify the branding on the white T-Shirt. The number of participants providing guesses rather than saying they could not identify anything was the most frequent at 2 metres. This shows support again that the smaller the distance, the better the visibility, even if what they were able to see was still blurred. The reduced visibility may be due to the thin font size, despite reaching across the chest, the letters were not large enough to be identified in these conditions.

The next subject to be discussed is the Blue Hooded Sweatshirt, an image of this can be seen in Appendix J. The First-Generation doorbell images can be seen in Slide 19-

21, Second-Generation doorbell images can be seen in Slides 22-24 and Video Doorbell plus images in 25-27, all in Appendices E and F.

The First-Generation doorbell again provided no correct answers across either participant group. At 6 metres, not one participant could identify any branding. Whilst at 4 metres, only three participants answered with a description, one stated, ‘Nike tick’, ‘white band’ and ‘image in the centre’. As previously discussed, the footage recorded at 4 and 6 metres on this doorbell were very low quality and the subject was blurred to the point it was almost not visible. This explains the lack of branding identification. Meanwhile, at 2 metres, when visibility increased, there were still no correct answers and even less guesses, with only one participant answering, ‘hoody’. The issue with this doorbell and the reflection affected how well participants were able to identify the colour of the sweatshirt and may have made the branding not visible.

For the Second-Generation doorbell, at 6 metres, 2 participants in Group 1 successfully identified the branding on the sweatshirt as ‘GAP’. Interestingly, in Group 2, no participants identified the branding at 6 metres; many discussed how the ‘writing is white’ but could not further identify anything. Meanwhile, at 4 metres, 17 participants across both groups recognised the branding which further jumped to 34 participants at 2 metres. This can be attributed once again to the smaller distance between the subject and the camera.

On the other hand, the Video Doorbell Plus, across both groups, 12 participants identified the branding correctly at 6 metres. Increasing to 22 at 4 metres and 36 at 2 metres. The reasoning for this is as discussed above. However, as these numbers are larger than those from the Second-Generation, the video quality could be a contributing factor to the improvement of the visibility.

To sum up, the fact that distance affects visibility is consistently shown throughout the findings with the Blue Hooded Sweatshirt. As also previously demonstrated, as distance decreases, the visibility increases. This is the same for the video quality of the doorbell cameras.

Finally, the last subject to be focused on in this section is the Black Sweatshirt displayed in Appendix M. The First-Generation doorbell images can be seen in Slide 28-30, Second-Generation doorbell images can be seen in Slides 31-33 and Video Doorbell plus images in 34-36, all in Appendices E and F.

Similar to previous findings, at 6 metres on the First-Generation Video Doorbell, no participants across the groups could identify the branding. This was the same for 4 metres, although some suggestions were made such as ‘GAP’ once again. At 2 metres, other suggestions were made such as ‘supreme’, ‘DSQUARED’, ‘tommy Hilfiger’ and ‘slazenger’. Despite these, none were correct. When viewing the images, as previously discussed, the video quality is poor and therefore the subject is barely visible, and only can really be seen at 2 metres. Despite this, the image is too blurred to identify any branding successfully.

For the Second-Generation Ring Doorbell, across all distances, not one participant correctly identified the branding. Most participants identified that there was a ‘white rectangle with a dark border’ or ‘white writing’ but were unable to say what it was. In this instance, the distance can not be identified as a contributing factor, of improving the visibility as even when the images are cropped, the logo does not appear any clearer and is still blurred. As the branding is in white writing, it does appear that the camera does not pick it up and instead reflects it causing more issues with identification, as previously seen with the White T-Shirt.

Regarding the Video Doorbell Plus, the results were the same as the Second-Generation doorbell in that, across all distances the branding was not identified. The number of guesses does not significantly change from distance to distance either. The logo is still blurred and too small to identify any branding on the images and therefore cannot be attributed solely to the distance or night vision for participant failure to identify any branding.

Overall, not one participant could successfully identify the branding and what the sweatshirt said. Only aspects such as that it was in a box or was white writing. For this subject, the branding was simply too small to be in focus and identifiable even when

at the closest distance of 2 metres. The issue with the white writing being reflected is also apparent again in this subject much like the colour of the White T-Shirt. Therefore, in this case, it cannot be said that distance or the night vision made a sole difference to the visibility of the branding on the Black Sweatshirt.

In conclusion, the branding on the subjects was most identified on the Blue Hooded Sweatshirt. This was due to the big letters on the sweatshirt that were visible from 6 metres away from the camera from the Second-Generation and the Video Doorbell Plus. The number of correct answers significantly increased as the distance between the subject and camera got smaller and as the video quality improved with the Video Doorbell Plus. The number plate was mostly reflected until the images from the Video Doorbell Plus where most could identify the number plate at 2 metres. These results are consistent evidence that distance does affect the visibility and it does so positively when the distance is small. Regarding the Black Sweatshirt and the White T-Shirt, no participants correctly identified either branding regardless of doorbell or distance. Both faced issues with reflection but the main issue was the limitations caused by the small font size of the Black Sweatshirt and the thin font of the White T-Shirt.

3.3. Enhanced or Unenhanced

This section will focus on Objective 3 and discuss the question, “Which image do you think it is easier to identify from?” The images in question were an enhanced version of a still image prepared using the ‘Levels’ tool in Amped FIVE software and an unenhanced version. Participant Group 1’s slideshow displayed the two versions, seen in Appendix E, whilst Participant Group 2 had the unenhanced image, the cropped version of the unenhanced image and then the enhanced image which was also cropped. This can be seen in Appendix F. As a result of these differences, Group 1 had the choice of either ‘Left’ or ‘Right’ whilst Group 2 had four options, Image ‘1’, Image, ‘2’, Image, ‘3’ or ‘None of the Above’. Another key difference was when enhancing the image that was shown to Group 2, the ‘Static Region’ tool was used which means only a specific area of the image was enhanced, there were the number plate specifically, and the area of branding present on each clothing item.

The first segment will focus on the visibility of the car, shown in Appendix I. The first Figure of results is shown below. The First-Generation doorbell images can be seen in Slide 1-3, Second-Generation doorbell images can be seen in Slides 4-6 and Video Doorbell plus images in 7-9, all in Appendices E and F.

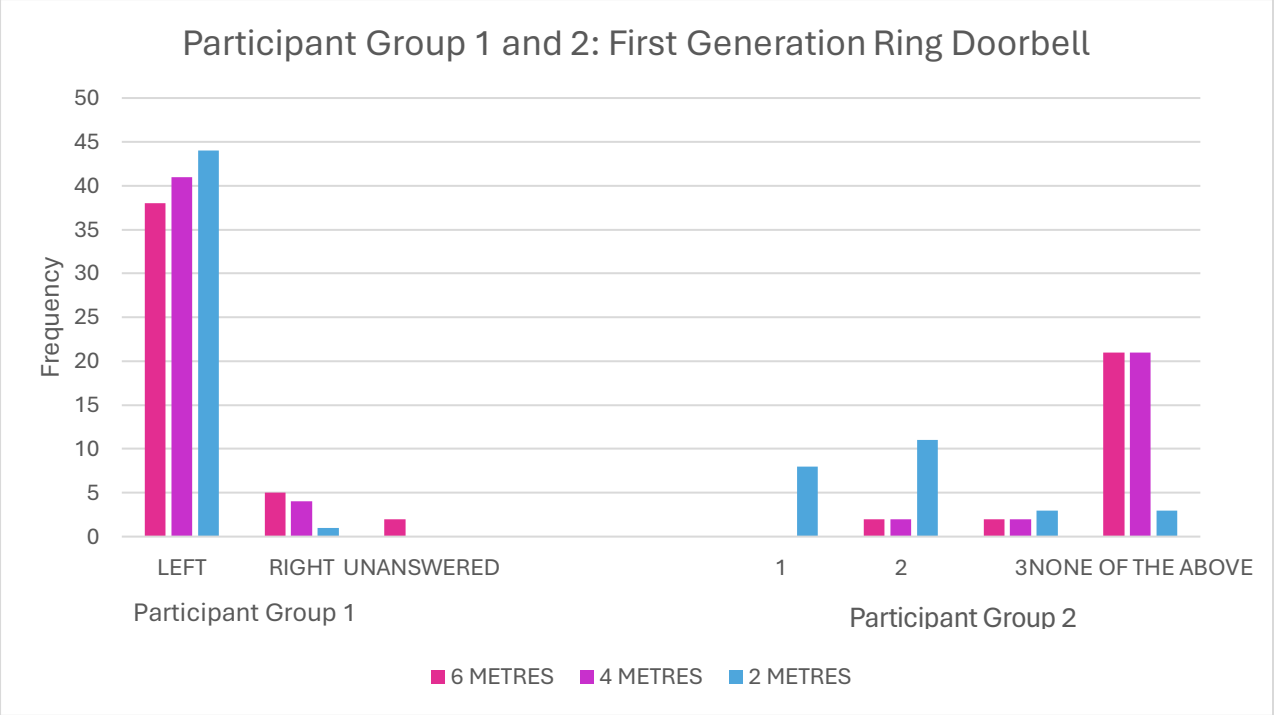

Figure 14: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the First-Generation Ring Doorbell

The most common answer for all distances for Participant Group 1 was 'Left'. The left image was the unenhanced version. Whilst Participant Group 2 most frequently chose 'None of the Above'. This can be attributed to the reflection that occurs on the number plate of the car, previously discussed in section 3.2, this means the area is overexposed and not visible; as the highlight levels are increased, it only makes visibility worse.

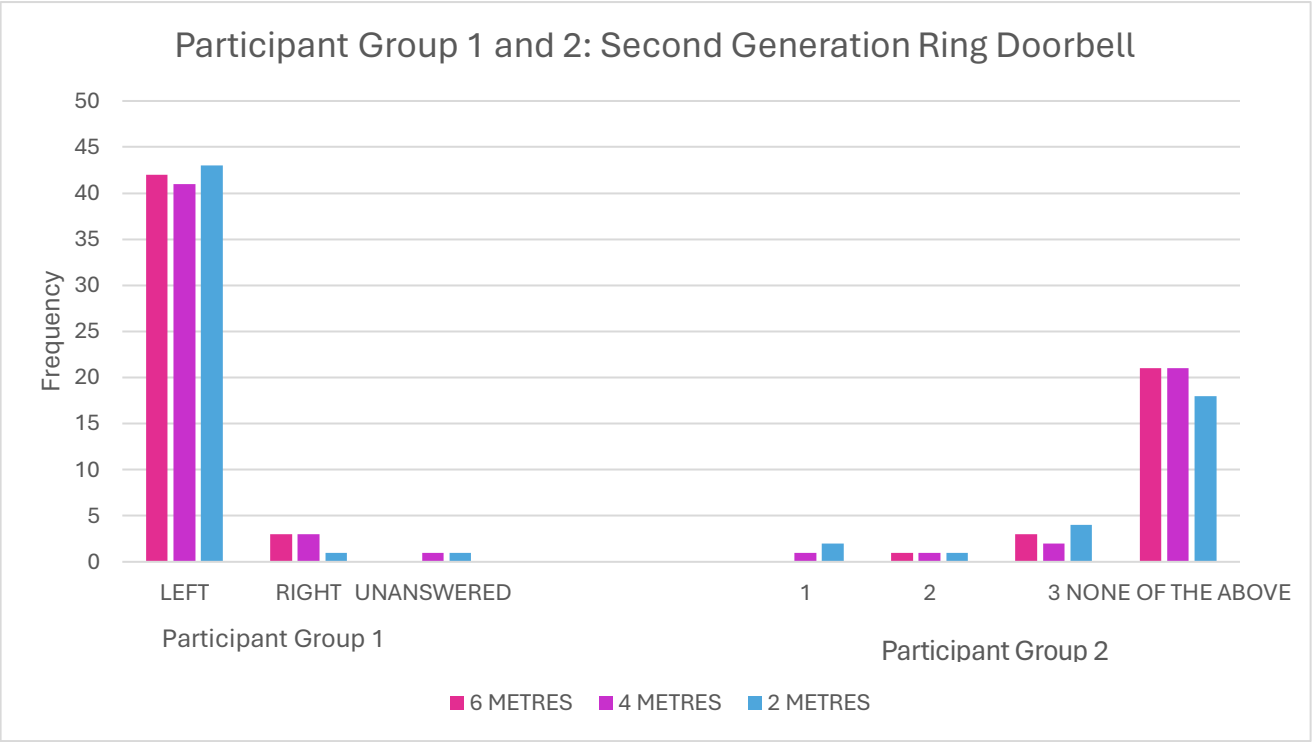

Figure 15: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the Second-Generation Ring Doorbell

Figure 15 displays that results for the Second-Generation Ring Doorbell are the same as the First-Generation as discussed above. The enhancements furthered the reflection present and meant the number plate could not be identified.

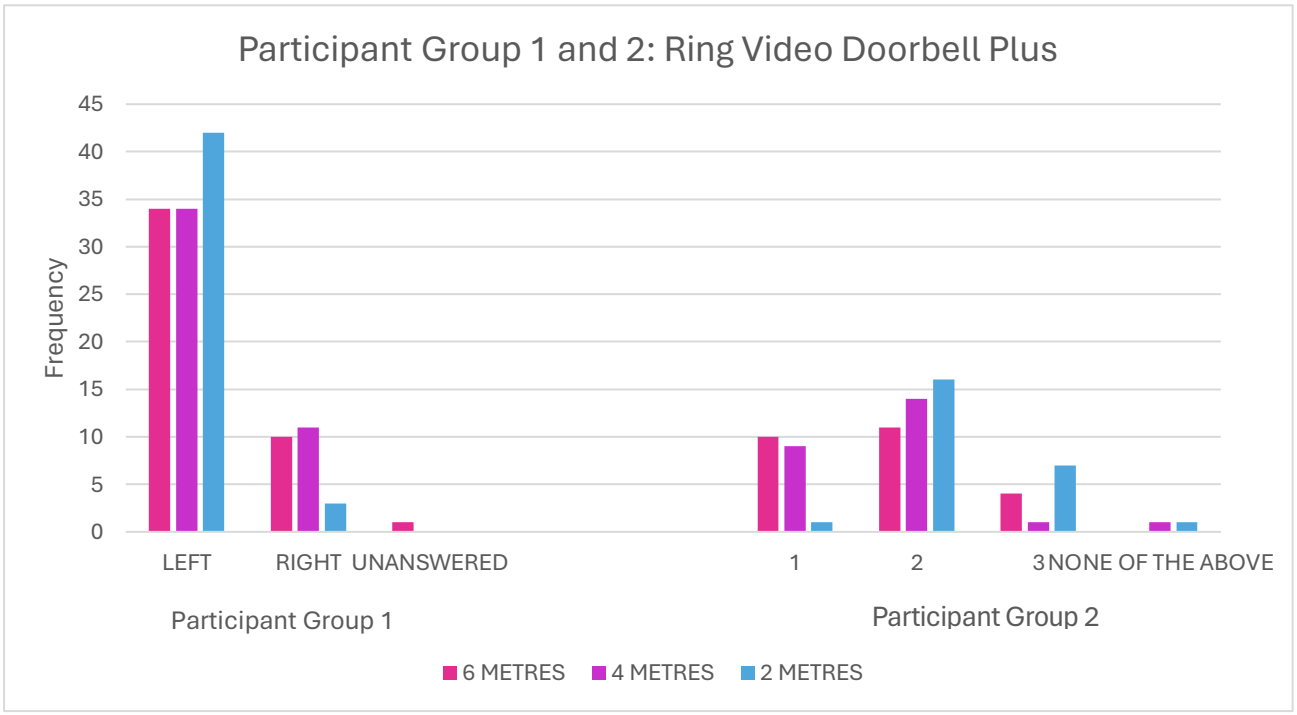

Figure 16: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the Ring Video Doorbell Plus

In Figure 16, the most common answer by Participant Group 1 was ‘Left’ which was unenhanced whilst Group 2 said Image ‘2’ which was the enhanced version. When comparing the images each group looked at, there are clear differences, they can be found on Slide 3 of Appendices E and F. In the image that Group 1 saw, the number plate is again overexposed and unreadable, however, due to the potential bias that may have affected the image quality, caused by the incorrect exporting of the images following enhancement, this result is to be disregarded and Group 2’s majority answer is to be accepted as the result. This also aligns with the results found for the Video Doorbell Plus in Section 3.1 and 3.2.

Overall, the participants on average did not believe that the enhanced version of the images were useful in increasing the visibility of the subject. However, the number plate in these images were already overexposed and therefore no enhancement would bring back the information lost. In comparison to the Video Doorbell Plus, where the enhancement makes a positive change in improving a dark area and allowing more participants to answer the questions correctly. This demonstrates that in an image that is not overexposed, enhancement using the ‘Levels’ tool can improve visibility.

The next section will focus on the White T-Shirt that can be seen in Appendix N. The First-Generation doorbell images can be seen in Slide 10-12, Second-Generation doorbell images can be seen in Slides 13-15 and Video Doorbell plus images in 16-18, all in Appendices E and F.

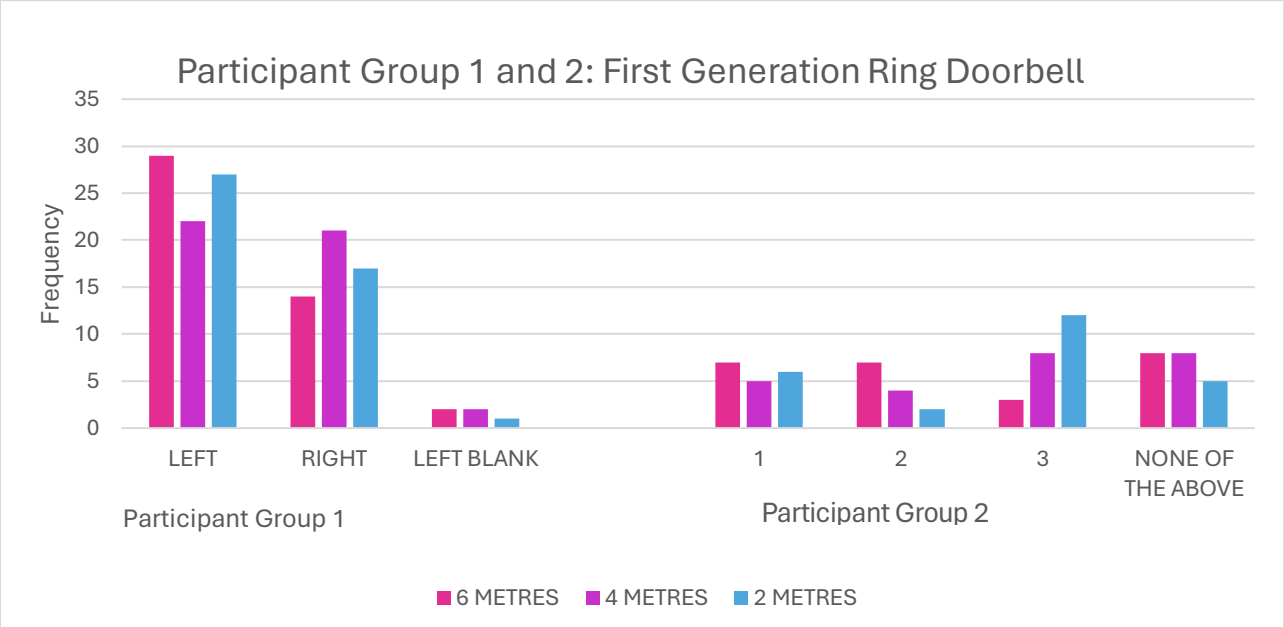

Figure 17: Participant Group 1 and 2’s Responses to the Question, “Which Image is Easier to Identify From?” Based on Images Captured via the First-Generation Ring Doorbell

In Figure 17, Group 1 believed across all distances, the 'Left', unenhanced image was the better option. For Group 2, at 2 metres, the most frequent answer was Image '3', this is the uncropped and unenhanced image. At 4 metres, 8 participants each said either Image '3' or 'None of the above'. Meanwhile, for 6 metres, the chosen image was also 'None of the above'.

The consensus was that the enhanced version did not improve the visibility of the T-Shirt. However, as discussed in Section 3.1 and 3.2, the T-Shirt reflects and results in the branding becoming overexposed and unidentifiable, this means once again, using the 'Levels' tool only worsened the issue. Additionally, to this, the poor video quality of the First-Generation Doorbell meant the individual wearing the T-Shirt was not visible at 4 or 6 metres away which explains the answers of 'None of the Above'.

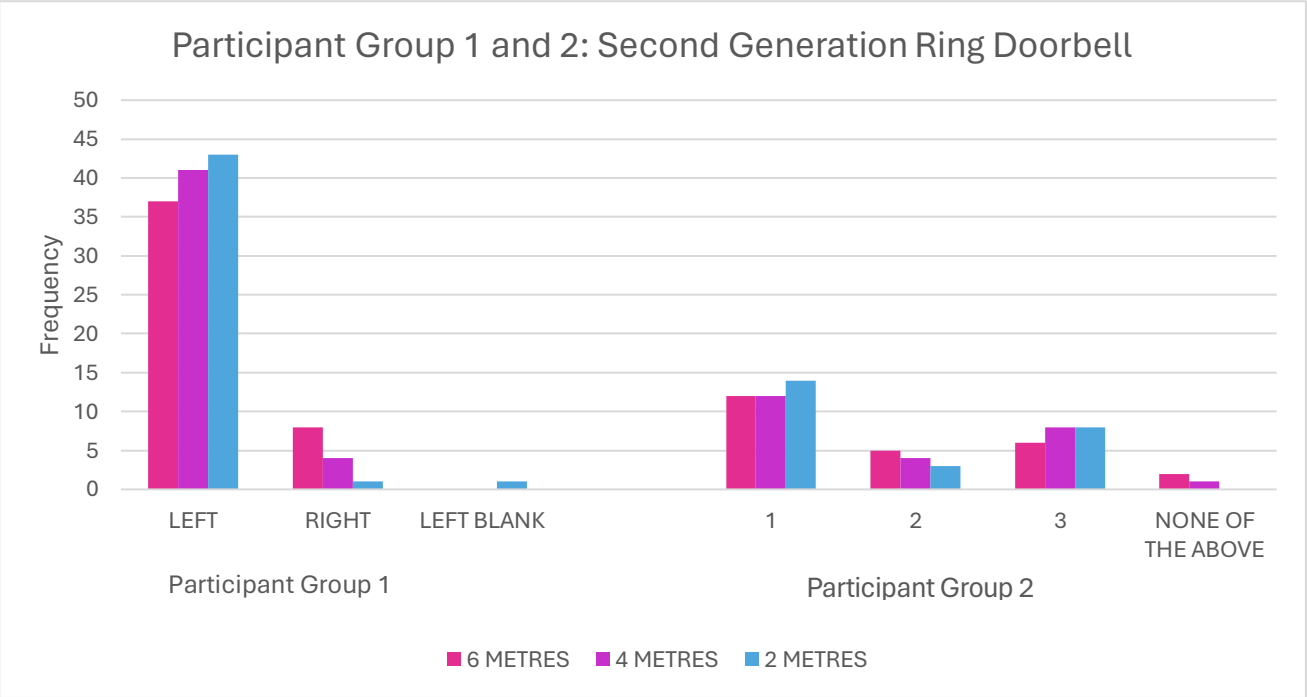

Figure 18: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the Second-Generation Ring Doorbell

Figure 18 displays results from the Second-Generation doorbell. Participant Group 1 most answered 'Left' across all distances. Whilst Group 2, said Image '1' the most, across the three distances. Both groups agreed that the unenhanced version did not improve the visibility. Due to varying factors the subject was not identifiable. Some of

these factors include, the font being thin meaning it did not appear on the image, and blur caused by low resolution. As a result, when enhancing the image, there was no information to increase the visibility of. This explains why the majority of participants did not choose the enhanced version.

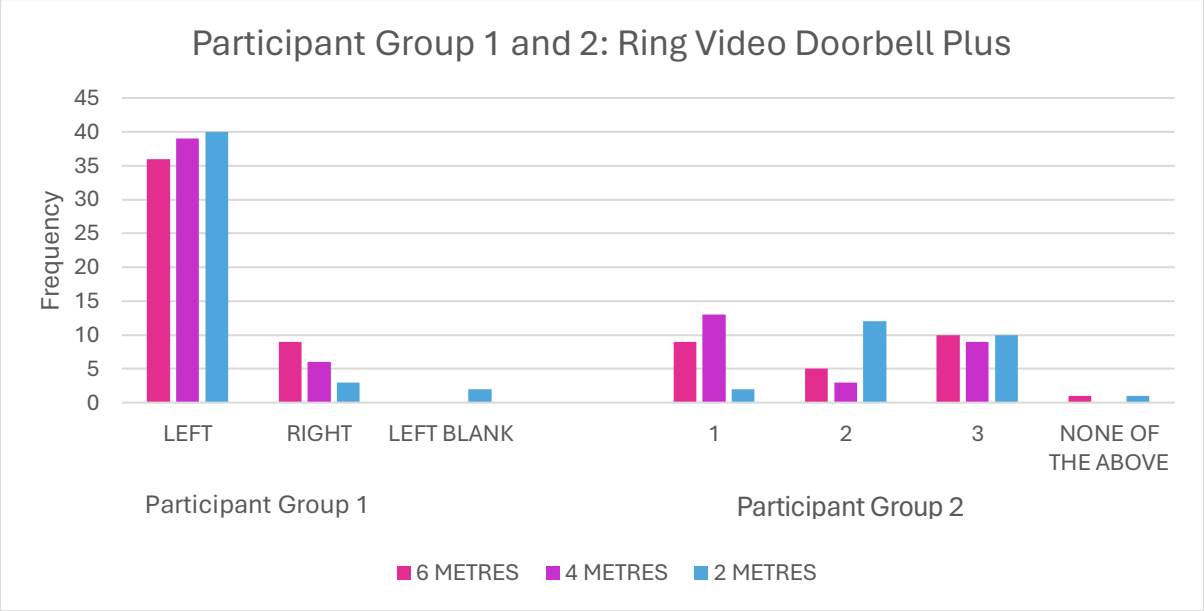

Figure 19: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the Ring Video Doorbell Plus

Figure 19 displays results from the Video Doorbell Plus. It can be seen that Group 1 mostly chose that the 'Left', unenhanced image. Whilst Group 2, at 6 metres chose Image '3', at 4 metres chose Image '1' and at 2 metres, Image '2'. As previously discussed, the already White T-Shirt causes overexposure when the highlights are lifted, this explains Group 1's answers. However, Group 2 answered differently for each distance. Despite choosing the enhanced image at 2 metres as preferable, they failed to identify any branding correctly. As a result, it cannot be assumed that the enhanced version improves the visibility of the subject.

To conclude, for the White T-Shirt, the enhancement of the still image does not improve the overall visibility of the subject or specifically, the ability to identify any branding. This may be due to the colour of the T-Shirt or the size of the font, but it can not be determined.

The next section will be discussing the Blue Hooded Sweatshirt seen in Appendix J. The First-Generation doorbell images can be seen in Slide 19-21, Second-Generation doorbell images can be seen in Slides 22-24 and Video Doorbell plus images in 25-27, all in Appendices E and F.

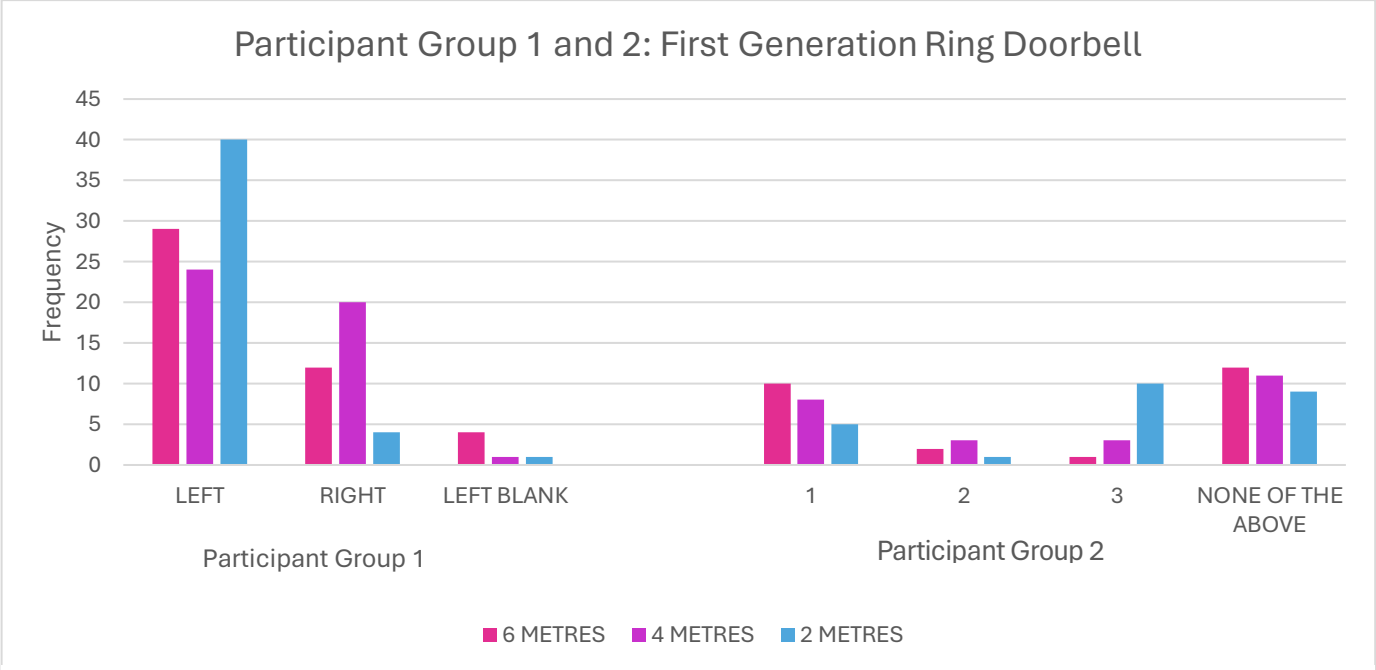

Figure 20: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the First-Generation Ring Doorbell

Shown in Figure 20, Participant Group 1 across all distances chose the 'Left' unenhanced image. Whilst Group 2, at 6 and 4 metres, chose 'None of the Above' and at 2 metres, chose Image '3'. No participant chose the correct answer and were unable to identify any branding from these set of images. It can be assumed, as previously discussed, that the poor quality of the camera contributed to the low visibility of these images as the individual is unable to be seen until 2 metres away from the camera and that the image is too blurred to observe.

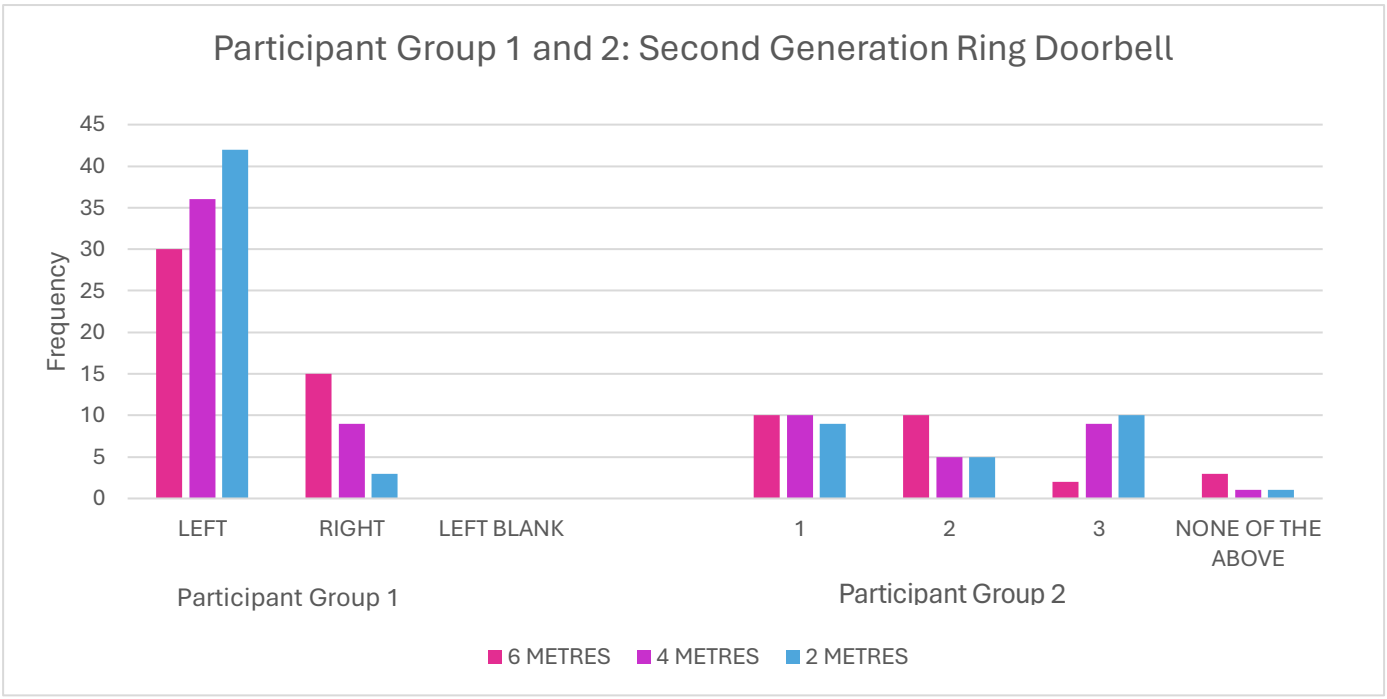

Figure 21: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the Second-Generation Ring Doorbell

In the above Figure, the majority of Group 1, once again believed the 'Left' unenhanced image was preferable. On the other hand, at 6 metres, in Group 2, 10 participants said Image '1' was better and 10 also said Image '2' was the easiest to identify from. At 4 metres, 10 chose Image '1' again and at 2 metres, the most common was Image '3'. At 4 metres, 17 participants correctly identified the branding, this means that the cropping of the image improved the visibility, but it can not be said whether the enhancement improved the visibility due to the split voting. At 2 metres, participants preferred the uncropped and unenhanced image and were able to identify the branding without the enhancements.

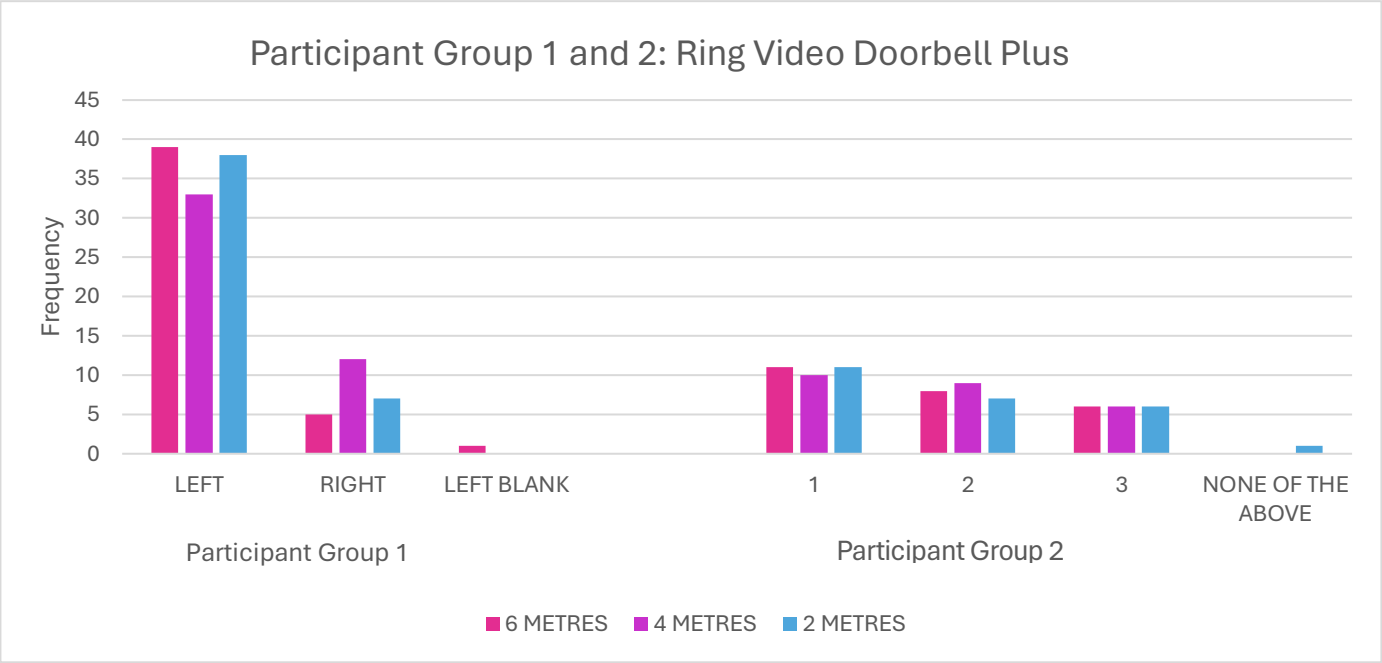

Figure 22: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the Ring Video Doorbell Plus

Figure 22 displays results for the Video Doorbell Plus. Group 1, identified again that the 'Left' image is the most preferable choice whilst Group 2 also agreed, across all distances. Whilst each enhanced image was not the preferable choice for the participants to identify from, the number of correct answers increased with the use of this doorbell, as seen in Section 3.2, as a result, it can be identified that the improved in quality and the use of the coloured night vision was the contributing factor to the improvement in visibility rather than the enhancements done in Amped FIVE.

In summary, throughout each doorbell, Group 1 consistently chose the unenhanced image as the easier to identify from. Meanwhile, in Group 2, the enhanced image was only chosen most frequently once which was for the Second-Generation doorbell at 6 metres. The enhanced version was not preferable for the Video Doorbell Plus but this may be due to the improvement in video quality and use of coloured night vision meaning enhancement was not needed as the subject could be identified without it. Overall, for the Blue Hooded Sweatshirt, the use of the 'Levels' tool in Amped FIVE has not improved the overall visibility and likelihood of identification of this subject.

The final section will focus on the which image the participants found easier to identify the Black Sweatshirt from, as seen in Appendix M. The First-Generation doorbell images can be seen in Slide 28-30, Second-Generation doorbell images can be seen in Slides 31-33 and Video Doorbell plus images in 34-36, all in Appendices E and F.

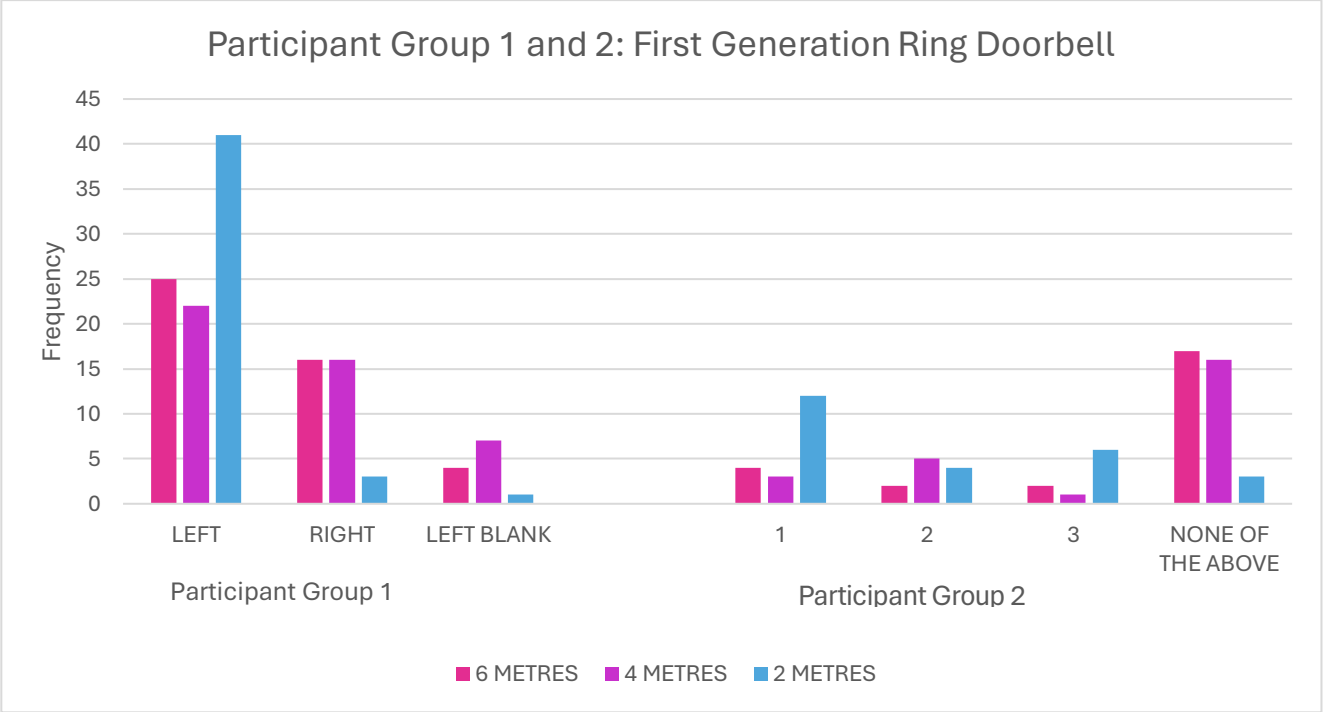

Figure 23: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the First-Generation Ring Doorbell

As shown in Figure 23 above, Group 1, across all distances once again believed that the 'Left' unenhanced image is easier to identify from. Meanwhile, Group 2 most frequently identified 'None of the Above' for 6 and 4 metres. Whilst, for 2 metres, Image '1' was most chosen. As discussed above, the individual wearing the Black Sweatshirt is not visible until 2 metres away from the camera, this explains why the enhancement does not improve visibility as there is nothing there that is visible to improve, this is due to the poor video quality of the First-Generation camera. Meanwhile, at 2 metres, it was also mentioned before that the white writing reflected in the image and increasing the highlights would worsen this. As a result, the cropped image was chosen as it makes the branding more visible but not clear enough to be able to decipher what the branding is.

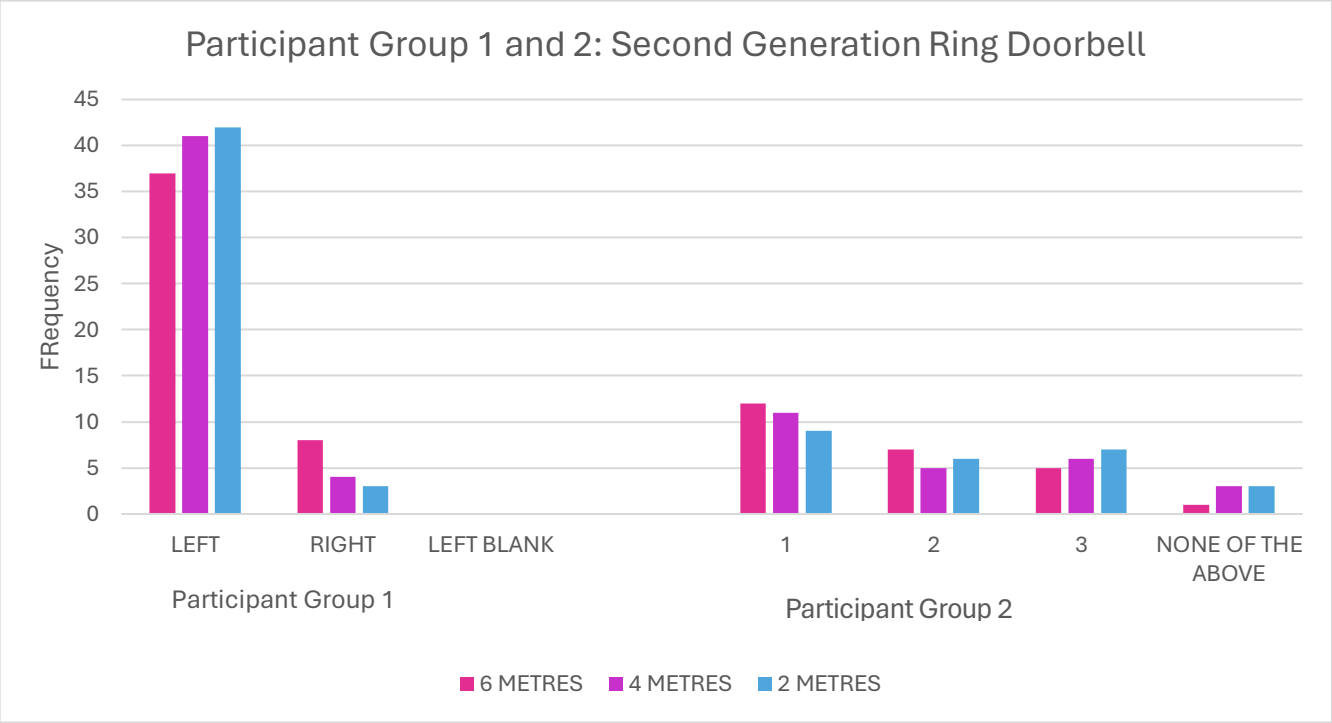

Figure 24: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the Second-Generation Ring Doorbell

Figure 24, as shown above showcases the findings for the Second-Generation Doorbell for the Black Sweatshirt. Participant Group 1 once again chose the 'Left' unenhanced image as the favourable option across all distances. Whilst Image '1' was chosen across the three distances for Group 2. For this section as discovered in Section 3.2, not once participant correctly estimated what the branding was. The branding was too small to be identified and was white writing which reflected in the images. As a result, once again, enhancement through Amped FIVE did not improve the quality of the image which was reflected in these results again.

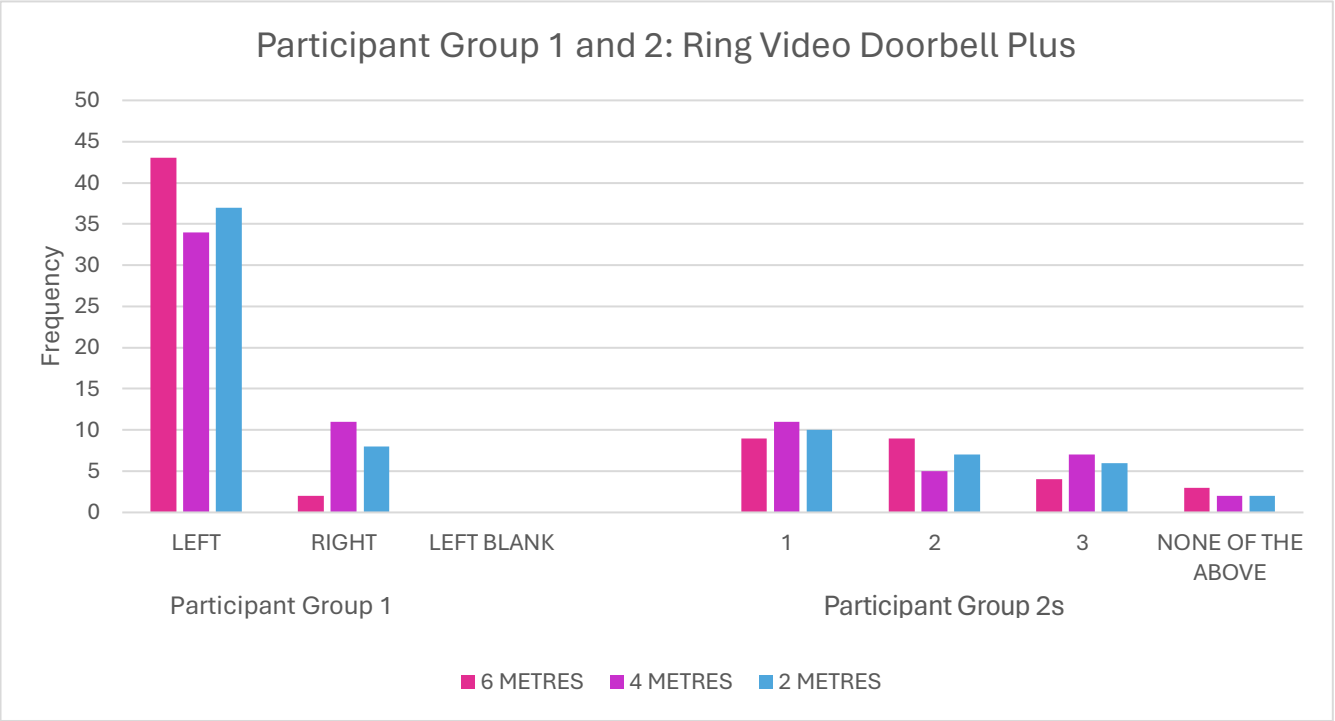

Figure 25: Participant Group 1 and 2's Responses to the Question, "Which Image is Easier to Identify From?" Based on Images Captured via the Ring Video Doorbell Plus

In the final graph, Figure 25 displays the results for the Video Doorbell Plus. Group 1 most commonly chose the 'Left' unenhanced image whilst Group 2 chose Image '1' most frequently. With these results, it can be said that although the use of the 'Levels' tool has not been preferred, the cropped image has been largely chosen over the untouched raw image. Overall, the small size and lack of clarity of the branding was at fault for the branding not being identified in these images as they faced the issue of reflection being worsened with the enhancements once again.

Overall, the enhancements using the 'Levels' tool was not once chosen as the preferred choice for improving the visibility of the Black Sweatshirt. However, it can be said that the use of the cropping tool to scale the subject up was beneficial and was often chose as the image the participants identified to be the easiest to read from.

To conclude, on average, the image enhanced with the use of the 'Levels' tool in Amped Five was not most chosen to improve the visibility of the images. The number plate faced issues with reflection which made enhancements redundant due to the overexposure. Meanwhile, the White T-Shirt and the Black Sweatshirt both also faced issues with reflection but mainly the small or thin font leading to a blurred image and unidentifiable branding that could not be saved with the enhancements. For the Blue Hooded Sweatshirt, the branding was being identified from the Second-Generation

doorbell onwards which was not improved via the enhancements either. It is to be considered that the upgrade in overall camera quality and the coloured night vision of the Video Doorbell Plus rendered the need for the enhancements futile and it was rather the cropping of the image that aided the participants in the identifications.

3.4. Context to Previous Research

The previous research surrounding this topic is limited. However, the results of the coloured night vision being the favourable option is supported by Hogervosrt, M and Toet, A in 2008, who discussed that imagery that is in colour allows for better detection of scenes and objects. Moreover, the common issue of distance within surveillance can be linked to various facial recognition research that often discuss the effect of distance on visibility. Wheeler, F, Weiss, R and Tu, P in 2010 mentioned how distance was one of their main issues within their field of research and that they aimed to effectively distance cover a large area for the detection of persons. Furthermore, the paper by Grgic, M, Delcac, K and Grgic, S in 2009, considers how distance affected their research and how the quality of the images changed.

3.5. The Application to Future Digital Forensics

This section will aim to address Objective 4. It is important to point out that one of the main findings from this research is the benefits from using the Video Doorbell Plus over the older generation doorbells. This not only includes the increased 1536p video quality and use of HD but also the colour night vision which increased the visibility of the subjects most frequently. This displays to police forces that there is a need to demonstrate to the public how beneficial an upgrade in their at-home smart doorbell could be. Not only for capturing crime but also for use as evidence in criminal investigations. The findings about how visibility improves based on the smaller the distance between subject and camera can also be demonstrated to the public and showcase how the position that home surveillance is being placed can improve chances of capturing a subject. This is especially important if members of the public are unable to upgrade and do have an older generation doorbell due to the downgrade in video quality. Moreover, the use of Amped FIVE to enhance an image should be considered as seen with the number plate, when reflection does not occur, it can improve the visibility, but it is worth an attempt if a subject is underexposed.

3.6. Research Limitations

Examples of limitations that occurred in this research were during the data collection from participants. They were asked to record what device they were using and how they were using it to view the slideshow presentation. Answers varied from, computers to laptops and some were using it full screen, split screen or switching between tabs. Furthermore, this question was not asked to Participant Group 1 so that information was not recorded. This was a factor that could've created bias in their answers but could not be controlled due to the lack of time or capability to standardise this. Moreover, due to all using different screens, they may have been calibrated differently across devices which could cause colour to appear different. This also may have caused bias. Participants were also asked to rate their eyesight, if a participant had poor eyesight and it was not properly corrected, they may have not provided the same answers if they had their vision corrected or compared to someone who needed no correction. A limitation within the recording of the research was the lighting that was present from the streetlamp and how this may have affected how the subjects were captured at 6 metres. On the other hand, light present from inside the house or from neighbouring properties could not be controlled and may have altered visibility in a way that could not be controlled.

Conclusion

The aim of this research project was to investigate if aspects of varying subjects can be identified in night-time footage captured on three different Ring Video Doorbells. The first objective was to explore how distance affects the visibility of subjects recorded on the doorbells. As demonstrated in Sections 3.1 and 3.2, the distance had a direct effect on the quality of the footage recorded at night-time and therefore proves that this research concluded that distance did affect the visibility of the subjects. This was particularly the case with footage captured by First Generation doorbell where at 4 and 6 metres, the subject often become unidentifiable, and it could not be located in the images. This improved via the use of the Second-Generation doorbell as a result of the increased resolution leading to better quality image and an improvement in the ability to see subjects from further away. This advancement continued with the Video Doorbell Plus. These findings allowed the colour of the subjects to be identified as well

as branding on clothing, and numbers and letters of a number plate in night-time footage. As a result of these findings, Hypothesis 1a can be accepted and Hypothesis 1b can be rejected.

The second objective was to evaluate the use of infrared night vision against colour night vision at improving visibility in night-time footage recorded by the doorbells. From the findings it can be concluded that the use of colour night vision was favourable in improving visibility compared to infrared night vision. This is demonstrated throughout Section 3.1 where participants were more capable of correctly identifying the colour of the subject in the footage produced from the Video Doorbell Plus which utilises coloured night vision compared to the First- and Second-Generation doorbell that use infrared. Consequently, Hypothesis 2a can be accepted and Hypothesis 2b be rejected.

The third objective was to investigate the use of the 'Levels' tool in Amped FIVE to see if visibility can be improved. Throughout the research, there was issues faced regarding reflection mainly with the number plate and the White T-Shirt that meant the subject was overexposed and further enhancement would not improve the visibility as the information had already been lost due to being too bright. The font on the T-Shirt was also too thin for the camera to pick up on so once again, enhancement was futile. Furthermore, the Black Sweatshirt saw similar results, but it was discovered that the cropped image was favoured to identify the subjects from. For the Blue Hooded Sweatshirt, it was often found that as the video quality improved with each doorbell, the need for enhancement was not necessarily due to the subject being visible to the participant without it. To summarise, the enhancements via Amped FIVE were deemed not beneficial in improving the visibility of the subjects. This means Hypothesis 3a is to be rejected and Hypothesis 3b can be accepted.

Finally, Objective 4 was addressed in Section 3.5 which discussed how the findings of this research can be took further and applied to digital forensics and police investigations.

Further Work

A suggestion for further work for this research project is to compare a different brand of smart doorbell and see how this compares to the results from this study.

Additionally, use a different software to enhance the images and see whether the level of visibility changes between results.

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Appendices

Appendix A – Disclaimer Ethics Form

RESEARCH ETHICS

Disclaimer Form

The following declaration should be made in cases where the researcher and the supervisor (where applicable) conclude that it is not necessary to apply for ethical approval for a specific research project.

PART A: TO BE COMPLETED BY RESEARCHER

Name of Researcher:	Emma Mae Carter
School	Staffordshire University - School of Justice, Security and Sustainability

Student/Course Details (If Applicable)		
Student ID Number:		21012690
Name of Supervisor(s)/Module Tutor:		Dean Northfield
PhD/MPhil project: ☐		
Taught Postgraduate Project/Assignment: ☐	Award Title:	BSc Forensic Investigation
Undergraduate Project/Assignment: ☒	Module Title:	Forensic Research Project - FORE60369

Project Title:	An investigation into how distance affects the readability of a number plate at night-time captured by a Ring Doorbell Camera		
Project Outline:	The main aim of this project is to discover how distance affects readability of a number plate in footage taken at night-time on a Ring Doorbell Camera following enhancements using Amped 5 software.		
Give a brief description of research procedure (methods, tests etc.)	A Ring Doorbell Camera will be used to capture footage at night-time of a number plate recorded at varying distances. The footage will then be enhanced using Amped 5 and observed to decide at which distance, the number plate is most and least readable.		
Expected Start Date:	5/10/2023	Expected End Date:	29/03/2024

Declaration

I/We confirm that the University's Ethical Review Policy has been consulted and that all ethical issues and implications in relation to the above project have been considered. I/We confirm that ethical approval need not be sought. I/We confirm that:

The research does not involve human or animal participants	☒
The research does not present an indirect risk to non-participants (human or animal).	☒
The research does not raise ethical issues due to the potential social or environmental implications of the study.	☒
The research does not re-use previously collected personal data which is sensitive in nature, or enables the identification of individuals.	☒
Has a risk assessment been completed for this project?	☒ Yes ☐ N/A

Signature of Researcher:	Emma Mae Carter	Date:	12/10/2023
Signature(s) of Project Supervisor(s) (If student) OR Signature of Head of Department/ Senior researcher (if staff)	Dean Northfield	Date:	03/01/24

NB: If the research departs from the protocol which provides the basis for this disclaimer then ethical review may be required and the applicant and supervisor (where applicable) should consider whether or not the disclaimer declaration remains appropriate. If it is no longer appropriate an application for ethical review **MUST** be submitted.

Appendix B – Risk Assessment

V1-2023	TECHNICAL SERVICES SCIENCE HUB PROCEDURAL RISK ASSESSMENT

RESEARCH ETHICS
Disclaimer Form

The following declaration should be made in cases where the researcher and the supervisor (where applicable) conclude that it is not necessary to apply for ethical approval for a specific research project.

PART A: TO BE COMPLETED BY RESEARCHER

Name of Researcher:	Emma Mae Carter
School	Staffordshire University - School of Justice, Security and Sustainability

Student/Course Details (If Applicable)		
Student ID Number:		21012690
Name of Supervisor(s)/Module Tutor:		Dean Northfield
PhD/MPhil project: ☐		
Taught Postgraduate Project/Assignment: ☐	Award Title:	BSc Forensic Investigation
Undergraduate Project/Assignment: ☒	Module Title:	Forensic Research Project - FORE60369

Project Title:	An investigation into how distance affects the readability of a number plate at night-time captured by a Ring Doorbell Camera.		
Project Outline:	The main aim of this project is to discover how distance affects readability of a number plate in footage taken at night-time on a Ring Doorbell Camera following enhancements using Amped 5 software.		
Give a brief description of research procedure (methods, tests etc.)	A Ring Doorbell Camera will be used to capture footage at night-time of a number plate recorded at varying distances. The footage will then be enhanced using Amped 5 and observed to decide at which distance, the number plate is most and least readable.		
Expected Start Date:	5/10/2023	Expected End Date:	29/03/2024

1.1 Procedure:

- Academics or session lead to complete Risk Assessment for all practical classes/activities, Technical team for all support aspects this is then reviewed as required
- Researchers/Experimenters are to complete a Risk Assessment in consultation with their project advisor and technical staff as appropriate.
- No laboratory work is to commence without a suitable and comprehensive risk assessment being signed off by a competent person detailed in the laboratory handbook.
- Researchers/Experimenters to keep copies of Risk Assessments when working in the laboratories.

Notes:

- The risk assessment must be reviewed when any changes are made to the equipment, materials, procedure, personnel or if there is a near miss or accident
- Any staff member can stop experimental work if no risk assessment is in place, or if, in their opinion, there is a risk to safety. If anybody else has concerns, they must raise it immediately to a member of staff.
- Add rows as necessary
- If substances are used, then you must fill out the COSHH section 3-6. The COSHH regulations link is available here: - Control of substances hazardous to health (COSHH). The Control of Substances Hazardous to Health Regulations 2002 (as amended). Approved Code of Practice and guidance L5 (hse.gov.uk)

Risk assessment Reference **(Technical Services Only)**	

School/Service	Staffordshire University – School of Justice, Security and Sustainability		
Name	Emma Mae Carter	Supervisor name	Dean Northfield
Email address	c012690l@student.staffs.ac.uk	Supervisor email	d.northfield@staffs.ac.uk
level of study	Level 6	Course title	BSc Forensic Investigation
Module number	FORE60369	Module title	Forensic Research Project
Session/project title	An investigation into how distance affects the readability of a number plate at night-time captured by a Ring Doorbell Camera.		
Ethics approved (use BABAO for skeletal remains)	Yes ☐ No ☒		

Description of experimental procedure/practical session (500 words max)
The Ring Doorbell will be at a fixed position on a driveway, my preliminary work will include recording footage at night-time from the camera from 1 metre away to 10 metres away. The footage will be reviewed and the appropriate distances to be included in my project will be decided upon. Following this, the footage will be exported and uploaded to Amped 5 to be enhanced using varying light adjustment filters.

2 Risk Assessment

Risk assessment score

		Consequence				
		Negligible (minimal first aid only) 1	Minor (minor injuries) 2	Moderate (major injury) 3	Major (life changing injury) 4	Catastrophic (Danger of death) 5
Likelihood	Almost certain 5	5	10	15	20	25
	Likely 4	4	8	12	16	20
	Possible 3	3	6	9	12	15
	Unlikely 2	2	4	6	8	10
	Rare 1	1	2	3	4	5

2.1 Hazard list

Hazards inherent in the work, record details and possible injury: (e.g., Equipment, procedures, general chemical hazards, invertebrate work, body fluid sampling etc.)	Risk score	Record precautions which will be taken: (*e.g.,* Include any standard operating procedures, codes of practice, faculty policies you will be following) **Use Hierarchy of Control Measures to reduce risks.**	New risk score
Injury due to working near roads and cars	12	Take care and precaution when working and recording near road, preferably work on driveway where there is no safety risk of injury due to vehicles.	2
Working at night-time	9	Work in a lit area and somewhere well-known to myself so I am not at risk of injury or threat to my safety.	2
Fatigue due to regular computer use	4	Take breaks often and ensure I am well rested and hydrated.	2

2.2 Who may be at risk?

Staff – Day shift	Staff – Out of hours	Postgraduate students	Undergraduate students	New or expectant mothers	Contractors	Public	Other, please state below
☐	☐	☐	☒	☐	☐	☐	

2.3 What level of risk do you assign to this work?

Low	Medium Low	Medium	High
☐	☒	☐	☐

If the risk assessment is classified as high, then **no work** is to be undertaken. First, follow hierarchy of controls to reduce risks.
If no COSHH assessment is required, then please click here.

6 Emergency Plans

Do procedures require further emergency plans other than stated in codes of practice or standard procedure risk assessments? If yes, then state below	Yes ☐ No☒
Spills	
Fire	
First Aid	
Other	

7 Approval

Risk assessment completed by	Emma Mae Carter
Date submitted	24/10/2023
Supervisor (or session lead) approval signed	Dean Northfield
Date of supervisor approval	24/10/23
H&S approval signed	
Date of H&S approval	
Review date	
Any other comments	

Appendix C – Proportionate Ethics Form

RESEARCH ETHICS

Proportionate Review Form

The Proportionate Review process may be used where the proposed research raises only minimal ethical risk. This research must: focus on minimally sensitive topics; entail minimal intrusion or disruption to others; and involve participants who would not be considered vulnerable in the context of the research.

PART A: TO BE COMPLETED BY RESEARCHER

Name of Researcher:	Emma Mae Carter
School	Staffordshire University - School of Justice, Security and Sustainability

Student/Course Details (If Applicable)			
Student ID Number:			2101269
Name of Supervisor(s)/Module Tutor:			Dean Northfield
PhD/MPhil project:	☐		
Taught Postgraduate Project/Assignment:	☐	Award Title:	BSc Forensic Investigation
Undergraduate Project/Assignment:	☒	Module Title:	Forensic Research Project - FORE60369

Project Title:	Analysing Ring Doorbell Footage Captured at Night-Time For Subject Identification Using Amped Five Software		
Project Outline:	The main aim of this project is to assess the visibility of different subjects from varying distances, in night-time footage captured on three different Ring Doorbell cameras.		
Give a brief description of participants and procedure (methods, tests etc.)	Participants will be asked to view a slideshow presentation of the captured footage and answer the questionnaire provided based on their opinions		
Expected Start Date:	5/10/2023	Expected End Date:	29/03/2024

Relevant professional body ethical guidelines should be consulted when completing this form.

Please seek guidance from the School Ethics Coordinator if you are uncertain about any ethical issues arising from this application.

There is an obligation on the researcher and supervisor (where applicable) to bring to the attention of the School Ethics Coordinator any issues with ethical implications not identified by this form.

Researcher Declaration

I consider that this project has no significant ethical implications requiring full ethical review	☒

I confirm that:		
1.	The research will **NOT** involve members of vulnerable groups.	☒

	Vulnerable groups include but are not limited to: children and young people (under 18 years of age), those with a learning disability or cognitive impairment, patients, people in custody, people engaged in illegal activities (e.g. drug taking), or individuals in a dependent or unequal relationship.	
2.	The research will **NOT** involve sensitive topics. Sensitive topics include, but are not limited to: participants' sexual behaviour, their illegal or political behaviour, their experience of violence, their abuse or exploitation, their mental health, their gender or ethnic status. The research must not involve groups where permission of a gatekeeper is normally required for initial access to members, for example, ethnic or cultural groups, native peoples or indigenous communities.	☒
3.	The research will **NOT** deliberately mislead participants in any way.	☒
4.	The research will **NOT** involve access to records of personal or confidential information, including genetic or other biological information, concerning identifiable individuals.	☒
5.	The research will **NOT** induce psychological stress, anxiety or humiliation, cause more than minimal pain, or involve intrusive interventions. This includes, but is not limited to: the administration of drugs or other substances, vigorous physical exercise, or techniques such as hypnotherapy which may cause participants to reveal information which could cause concern, in the course of their everyday life.	☒
6.	The research **WILL** be conducted with participants' full and informed consent at the time the study is carried out: • The main procedure will be explained to participants in advance, so that they are informed about what to expect. ☒ • Participants will be told their involvement in the research is voluntary. ☒ • Written consent will be obtained from participants. *(This is not required for self-completion questionnaires as submission of the completed questionnaire implies consent to participate).* ☒ • Participants will be informed about how they may withdraw from the research at any time and for any reason. ☒ • For questionnaires and interviews: Participants will be given the option of omitting questions they do not want to answer. ☒ • Participants will be told that their data will be treated with full confidentiality and that, if published, every effort will be made to ensure it will not be identifiable as theirs. ☒ • Participants will be given the opportunity to be debriefed i.e. to find out more about the study and its results. ☒	YES ☒ N/A ☐
7.	A risk assessment has been completed for this research project	YES ☒ N/A ☐

If you are unable to confirm any of the above statements, please complete a **Full Ethical Review Form**. If the research will include participants that are **patients,** please complete the Independent Peer Review process.

8. Information and Data Please provide answers to the following questions regarding the handling and storage of information and data:
a) How will research data be stored (manually or electronically)? Electronically
b) How is protection given to the participants (e.g. by being made anonymous through coding and with a participant identifier code being kept separately and securely)? Identifiable characteristics will not be collected and they will remain anonymous
c) What assurance will be given to the participant about the confidentiality of this data and the security of its storage? No identifiable characteristics will be collected, they will be briefed on their right to confidentiality and how their answers will be stored
d) Is assurance given to the participant that they cannot be identified from any publication or dissemination of the results of the project? Yes
e) Who will have access to this data, and for what purposes? Myself as the researcher for analysis
f) How will the data be stored, for how long, and how will it be discarded? Data will be securely stored on University OneDrive account which is password protected. It will be kept until project marks are finalised and then be destroyed

Supporting Documentation

All key documents e.g. consent form, information sheet, questionnaire/interview schedule are appended to this application.	☒

Signature of Researcher:	Emma Mae Carter	Date:	01/03/2024

NB: If the research departs from the protocol which provides the basis for this proportionate review, then further review will be required and the applicant and supervisor(s) should consider whether or not the proportionate review remains appropriate. If it is no longer appropriate a full ethical review form **MUST** be submitted for consideration by the School Ethics Coordinator .

Next Step:

STUDENTS: Please submit this form (and supporting documentation) for consideration by your Supervisor/ Module Tutor.

STAFF: Please submit this form to your Head of Department or a Senior Researcher in your School. Once they have reviewed the form, this should be forwarded to the Research Administrators in RIIS (ethics@staffs.ac.uk) who will arrange for it to be considered by an independent member of the School's College of Reviewers .

PART B: TO BE COMPLETED BY SUPERVISOR/MODULE TUTOR (If student) OR Head of Department/ Senior Researcher (if staff)

I consider that this project has no significant ethical implications requiring full ethical review by the Faculty Research Ethics Committee.	☒
I have checked and approved the key documents required for this proposal (e.g. consent form, information sheet, questionnaire, interview schedule).	☒

Signature of Supervisor/ Head of Department/ Senior Researcher:	Dean Northfield	Date:	01/03/24

Next Step: Please forward this form to the Research Administrators in RIIS (ethics@staffs.ac.uk) who will arrange for it to be considered by an independent member of the School's College of Ethical Reviewers , having no direct connection with the researcher or his/her programme of study.

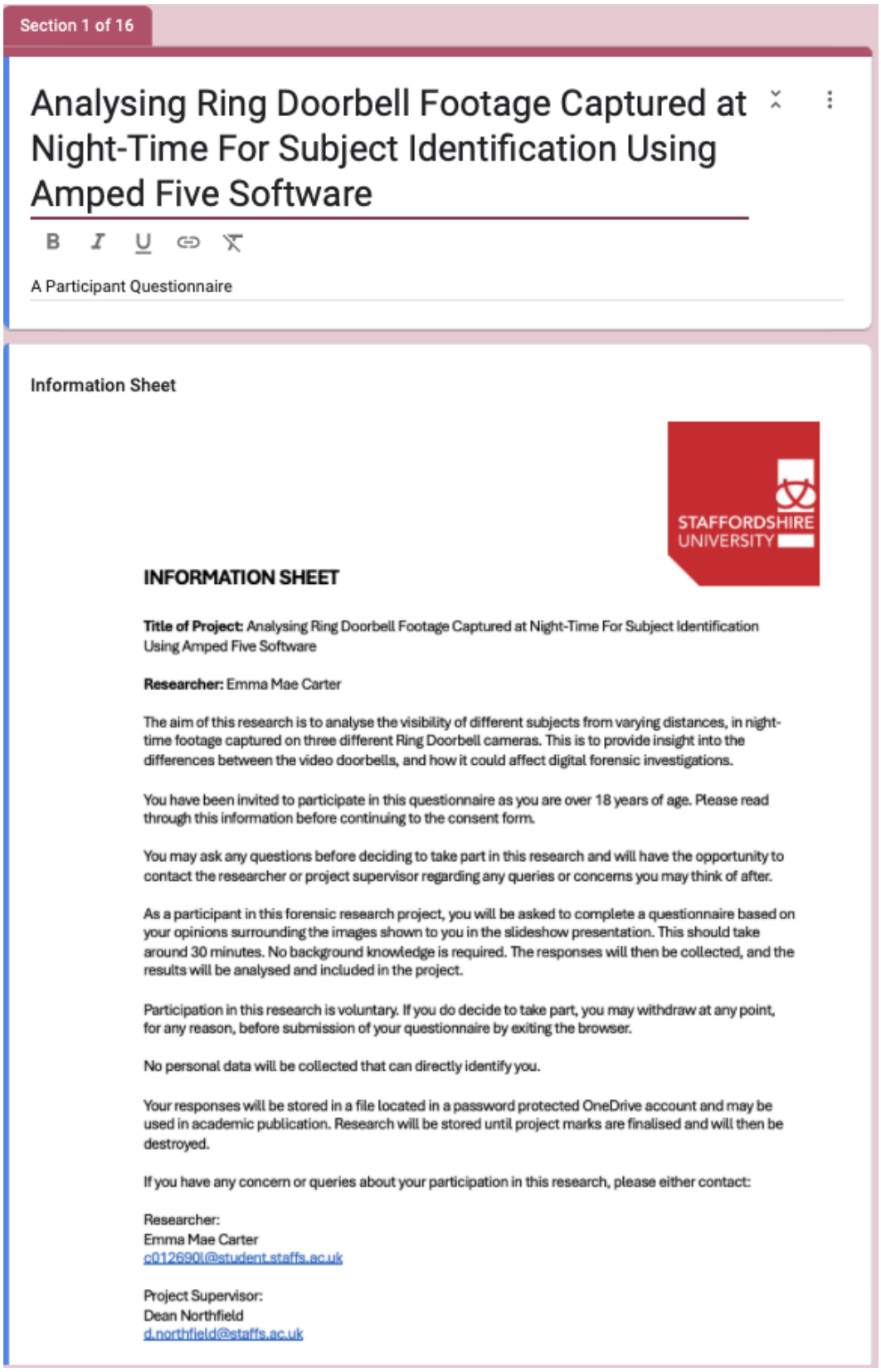
PART C: TO BE COMPLETED BY A MEMBER OF THE SCHOOL'S COLLEGE OF ETHICAL REVIEWERS

This research proposal has been considered using agreed University Procedures and is now approved. **Or** This research proposal has not been approved due to the reasons given below. N/A **Recommendation (delete as appropriate)**: Approve/ Amendments required/ Reject	☐ ☐

Name of Reviewer:	Dean Northfield	Date:	01/03/24
Signature:			

Signed (School Ethical Coordinator)		Date:	

Appendix D – Participant Questionnaire, including Consent Form and Information Sheet



Section 1 of 16

Analysing Ring Doorbell Footage Captured at Night-Time For Subject Identification Using Amped Five Software

A Participant Questionnaire

Information Sheet

INFORMATION SHEET

Title of Project: Analysing Ring Doorbell Footage Captured at Night-Time For Subject Identification Using Amped Five Software

Researcher: Emma Mae Carter

The aim of this research is to analyse the visibility of different subjects from varying distances, in night-time footage captured on three different Ring Doorbell cameras. This is to provide insight into the differences between the video doorbells, and how it could affect digital forensic investigations.

You have been invited to participate in this questionnaire as you are over 18 years of age. Please read through this information before continuing to the consent form.

You may ask any questions before deciding to take part in this research and will have the opportunity to contact the researcher or project supervisor regarding any queries or concerns you may think of after.

As a participant in this forensic research project, you will be asked to complete a questionnaire based on your opinions surrounding the images shown to you in the slideshow presentation. This should take around 30 minutes. No background knowledge is required. The responses will then be collected, and the results will be analysed and included in the project.

Participation in this research is voluntary. If you do decide to take part, you may withdraw at any point, for any reason, before submission of your questionnaire by exiting the browser.

No personal data will be collected that can directly identify you.

Your responses will be stored in a file located in a password protected OneDrive account and may be used in academic publication. Research will be stored until project marks are finalised and will then be destroyed.

If you have any concern or queries about your participation in this research, please either contact:

Researcher:
Emma Mae Carter
c0126901@student.staffs.ac.uk

Project Supervisor:
Dean Northfield
d.northfield@staffs.ac.uk

Section 2 of 16

Consent Form

Please answer all questions.

I have read and understood the information sheet *

- Yes
- No

I have been given the opportunity to ask questions, and I have had any questions answered satisfactorily. *

- Yes
- No

I understand that my participation in this study is entirely voluntary and that I can withdraw at any time up to the point of submission, without having to explain. *

- Yes
- No

I consent that the data collected could be used for publication in a scientific journal or could be presented in scientific forums (conferences, seminars, workshops) or used for teaching purposes and understand that all data will be presented anonymously. *

- Yes
- No

I agree that data will only be used for this project, although the data may also be audited for quality control purposes. *

- Yes

All data will be sorted safely on a password-protected OneDrive account and will be destroyed following the release of finalised project marks. *

- ○ Yes
- ○ No

I hereby give consent to take part in this study. *

- ○ Yes
- ○ No

After section 2 Continue to next section

Section 3 of 16

Before we begin...

It is recommended you view the slideshow on a computer monitor and in full screen view. Please refrain from discussing your answers with others.

Please rate your eyesight on the scale below, with 1 being perfect (no correction needed), to 5 being the worst (very poor eyesight). *

	1	2	3	4	5	
Perfect	○	○	○	○	○	Very Poor

Please state what device you are using to view the slideshow presentation. *

Short-answer text

How are viewing the slideshow presentation? *

- ○ Fullscreen
- ○ Split-screen
- ○ Switching between tabs

How are viewing the slideshow presentation? *

- ○ Fullscreen
- ○ Split-screen
- ○ Switching between tabs

After section 3 Continue to next section

Section 4 of 16

Part One - Section One

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 1. *
Write down any letters or numbers you can read from the number plate.

Short-answer text

Please refer to Slide 1. *
What colour do you think the car is?

Short-answer text

Please refer to Slide 1. *
Which image is it easier to read from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 2. *
Write down any letters or numbers you can read from the number plate

Please refer to Slide 2. *
Write down any letters or numbers you can read from the number plate.

Short-answer text

Please refer to Slide 2. *
What colour do you think the car is?

Short-answer text

Please refer to Slide 2. *
Which image is it easier to read from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 3. *
Write down any letters or numbers you can read from the number plate.

Short-answer text

Please refer to Slide 3. *
What colour do you think the car is?

Short-answer text

Please refer to Slide 3. *
Which image is it easier to read from?

- ○ 1
- ○ 2

Please refer to Slide 3. *
Which image is it easier to read from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

After section 4 Continue to next section

Section 5 of 16

Part One - Section Two

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 4. *
Write down any letters or numbers you can read from the number plate.

Short-answer text

Please refer to Slide 4. *
What colour do you think the car is?

Short-answer text

Please refer to Slide 4. *
Which image is it easier to read from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 5. *
Write down any letters or numbers you can read from the number plate.

Short-answer text

Please refer to Slide 5. *
What colour do you think the car is?

Short-answer text

Please refer to Slide 5. *
Which image is easier to read from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 6. *
Write down any letters or numbers you can read from the number plate.

Short-answer text

Please refer to Slide 6. *
What colour do you think the car is?

Short-answer text

Please refer to Slide 6. *
Which image is it easier to read from?

- ○ 1
- ○ 2

Please refer to Slide 6. *
Which image is it easier to read from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

After section 5 Continue to next section

Section 6 of 16

Part One - Section Three

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 7. *
Write down any letters or numbers you can read from the number plate.

Short-answer text

Please refer to Slide 7. *
What colour do you think the car is?

Short-answer text

Please refer to Slide 7. *
Which image is it easier to read from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 8. *
Which image is it easier to read from?

- 1
- 2
- 3
- None of the above

Please refer to Slide 9. *
Write down any letters or numbers you can read from the number plate.

Short-answer text

Please refer to Slide 9. *
What colour do you think the car is?

Short-answer text

Please refer to Slide 9. *
Which image is it easier to read from?

- 1
- 2
- 3
- None of the above

After section 6 Continue to next section

Section 7 of 16

Part Two - Section One

Section 7 of 16

Part Two - Section One

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 10. *
What colour is the T-Shirt the person is wearing in this image?

Short-answer text

Please refer to Slide 10. *
Can you identify anything about any branding on the T-Shirt?

Long-answer text

Please refer to Slide 10. *
What colour are the trousers the person in this image is wearing?

Short-answer text

Please refer to Slide 10. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ Option 3
- ○ None of the above

Please refer to Slide 11. *
What colour is the T-Shirt the person in this image is wearing?

Short-answer text

Please refer to Slide 11. *

Please refer to Slide 11. *
Can you identify anything about any branding on the T-Shirt?

Long-answer text

Please refer to Slide 11. *
What colour are the trousers the person in this image is wearing?

Short-answer text

Please refer to Slide 11. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 12. *
What colour is the T-Shirt the person in this image is wearing?

Short-answer text

Please refer to Slide 12. *
Can you identify anything about any branding on the T-Shirt?

Long-answer text

Please refer to Slide 12. *
What colour are the trousers the person in this image is wearing?

Short-answer text

Please refer to Slide 12. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

After section 7 Continue to next section

Section 8 of 16

Part Two - Section Two

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 13. *
What colour is the T-Shirt the person in this image is wearing?

Short-answer text

Please refer to Slide 13. *
Can you identify anything about any branding on the T-Shirt?

Long-answer text

Please refer to Slide 13. *
What colour are the trousers the person in this image is wearing?

Short-answer text

Please refer to Slide 13. *
Which image is it easier to identify from?

- ○ 1

Please refer to Slide 14. *
Can you identify anything about any branding on the T-Shirt?

Long-answer text

Please refer to Slide 14. *
What colour are the trousers the person in this image is wearing?

Short-answer text

Please refer to Slide 14. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 15. *
What colour is the T-Shirt the person in this image is wearing?

Short-answer text

Please refer to Slide 15. *
Can you identify anything about any branding on the T-Shirt?

Long-answer text

Please refer to Slide 15. *
What colour are the trousers the person in this image is wearing?

Short-answer text

Please refer to Slide 15. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

After section 8 Continue to next section

Section 9 of 16

Part Two - Section Three

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 16. *
What colour is the T-Shirt the person in this image is wearing?

Short-answer text

Please refer to Slide 16. *
Can you identify anything about any branding on the T-Shirt?

Long-answer text

Please refer to Slide 16. *
What colour are the trousers the person in this image is wearing?

Short-answer text

Please refer to Slide 16. *
Which image is it easier to identify from?

- ○ 1

Please refer to Slide 16. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 17. *
What colour is the T-Shirt the person in this image is wearing?

Short-answer text

Please refer to Slide 17. *
Can you identify anything about any branding on the T-Shirt?

Long-answer text

Please refer to Slide 17. *
What colour are the trousers the person in this image is wearing?

Short-answer text

Please refer to Slide 17. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 18. *
What colour is the T-Shirt the person in this image is wearing?

Please refer to Slide 18. *
What colour is the T-Shirt the person in this image is wearing?

Short-answer text

Please refer to Slide 18. *
Can you identify anything about any branding on the T-Shirt?

Long-answer text

Please refer to Slide 18. *
What colour are the trousers the person in this image is wearing?

Short-answer text

Please refer to Slide 18. *
Which image is it easier to identify from?

- 1
- 2
- 3
- None of the above

After section 9 Continue to next section

Section 10 of 16

Part Two - Section Four

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 19. *
What colour is the sweatshirt the person in this image is wearing?

Section 10 of 16

Part Two - Section Four

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 19. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 19. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 19. *
What colour are the shoes the person in this image is wearing?

Short-answer text

Please refer to Slide 19. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 20. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 20. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 20. *
What colour are the shoes the person in this image is wearing?

Short-answer text

Please refer to Slide 20. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 21. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 21. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 21.
What colour are the shoes the person in this image is wearing?

Short-answer text

Please refer to Slide 21. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

After section 10 Continue to next section

Section 11 of 16

Part Two - Section Five

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 22. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 22. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 22. *
What colour are the shoes the person in this image is wearing?

Short-answer text

Please refer to Slide 22. *
Which image is it easier to identify from?

- ○ 1

Please refer to Slide 22. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 23. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 23. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 23. *
What colour are the shoes the person in this image is wearing?

Short-answer text

Please refer to Slide 23. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 24. *
What colour is the sweatshirt the person in this image is wearing?

Please refer to Slide 24. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 24. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 24. *
What colour are the shoes the person in this image is wearing?

Short-answer text

Please refer to Slide 24. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

After section 11 Continue to next section

Section 12 of 16

Part Two - Section Six

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 25. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Section 12 of 16

Part Two - Section Six

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 25. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 25. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 25. *
What colour are the shoes the person in this image is wearing?

Short-answer text

Please refer to Slide 25. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 26. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 26. *

Please refer to Slide 26. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 26. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 26. *
What colour are the shoes the person in this image is wearing?

Short-answer text

Please refer to Slide 26. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 27. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 27. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 27. *
What colour are the shoes the person in this image is wearing?

Short-answer text

Please refer to Slide 27. *
Which image is it easier to identify from?

- 1
- 2
- 3
- None of the above

After section 12 Continue to next section

Section 13 of 16

Part Two - Section Seven

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 28. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 28. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 28. *
Which image is it easier to identify from?

- 1

Please refer to Slide 28. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 29. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 29. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 29. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 30. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 30. *
Can you identify anything about any branding on the sweatshirt?

Please refer to Slide 30. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 30. *
Which image is it easier to identify from?

- 1
- 2
- 3
- None of the above

After section 13 Continue to next section

Section 14 of 16

Part Two - Section Eight

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 31. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 31. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 31. *
Which image is it easier to identify from?

- 1

Please refer to Slide 31. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 32. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 32. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 32. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 33. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 33. *

Please refer to Slide 33. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 33. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 33. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

After section 14 Continue to next section

Section 15 of 16

Part Two - Section Nine

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 34. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 34. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Section 15 of 16

Part Two - Section Nine

Please use the slide numbers indicated by the text on the slides.

Please refer to Slide 34. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 34. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 34. *
Which image is it easier to identify from?

- ○ 1
- ○ 2
- ○ 3
- ○ None of the above

Please refer to Slide 35. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 35. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 35. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 35. *
Which image is it easier to identify from?

- 1
- 2
- 3
- None of the above

Please refer to Slide 36. *
What colour is the sweatshirt the person in this image is wearing?

Short-answer text

Please refer to Slide 36. *
Can you identify anything about any branding on the sweatshirt?

Long-answer text

Please refer to Slide 36. *
Which image is it easier to identify from?

- 1
- 2
- 3
- None of the above

After section 15 Continue to next section

Section 16 of 16

Thank you for your participation.

Please submit your answers below.

Appendix E – Participant Group 1: Slideshow Presentation

Research Project Questionnaire

Part One

Section One

1

2

3

Section Two

4

5

6

Section Three

7

8

9

Part Two

Section One

10

11

12

Section Two

13

14

15

Section Three

16

17

18

Section Four

19

20

21

Section Five

22

23

24

Section Six

25

26

27

Section Seven

28

29

30

Section Eight

31

32

33

Section Nine

35

34

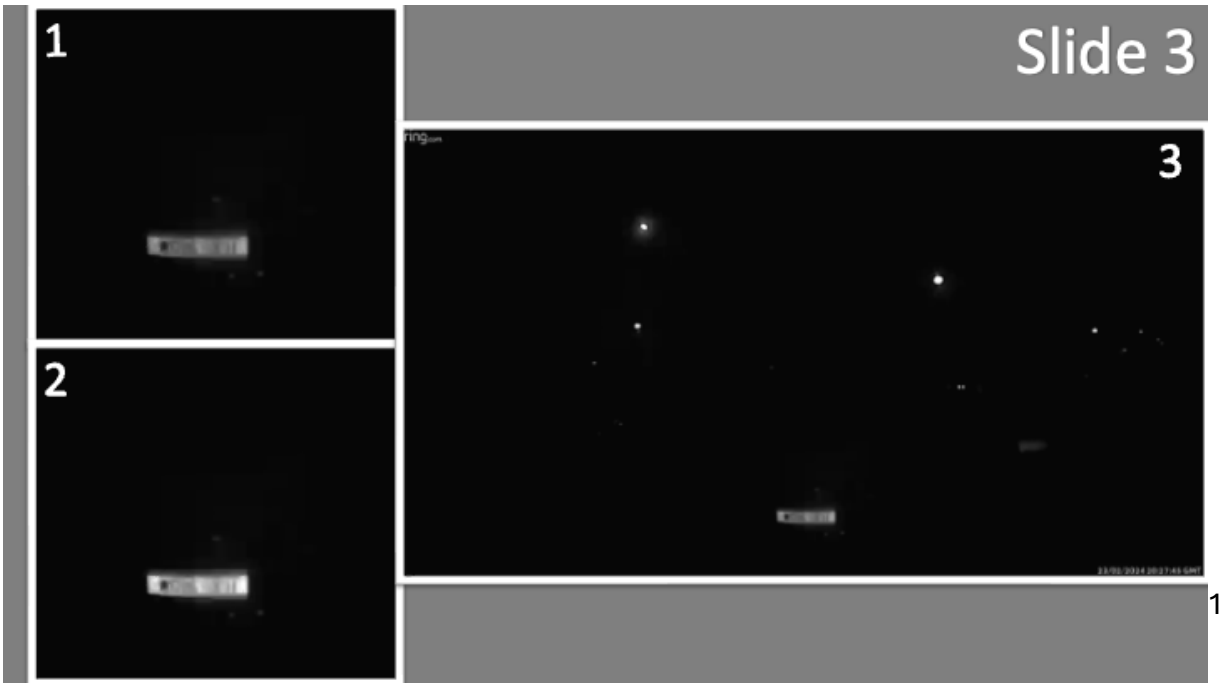
36

Thank you for your participation

Appendix F – Participant Group 2: Slideshow Presentation


1
2
Slide 1
3


1
2
Slide 2
3


1
2
Slide 3
3

Section Two

Slide 4

Slide 5


1
2
Slide 6
ring.com
3


Section Three


1
2
ring.com
3
Slide 7

Part Two

Section One

Slide 10

Slide 11

Section Two

Slide 14

Slide 15

Section Three

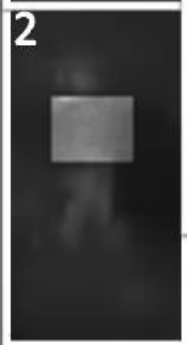
Slide 16

Slide 17

Slide 18

Section Four

Slide 19



Slide 20

Section Five

Slide 23

Slide 24

Section Six


1
2
ring.com
3
Slide 25


1
2
ring.com
3
Slide 26


1
2
ring.com
3
Slide 27

Section Seven


1
2
3
Slide 30


Section Eight


1
2
3
Slide 31

Slide 32

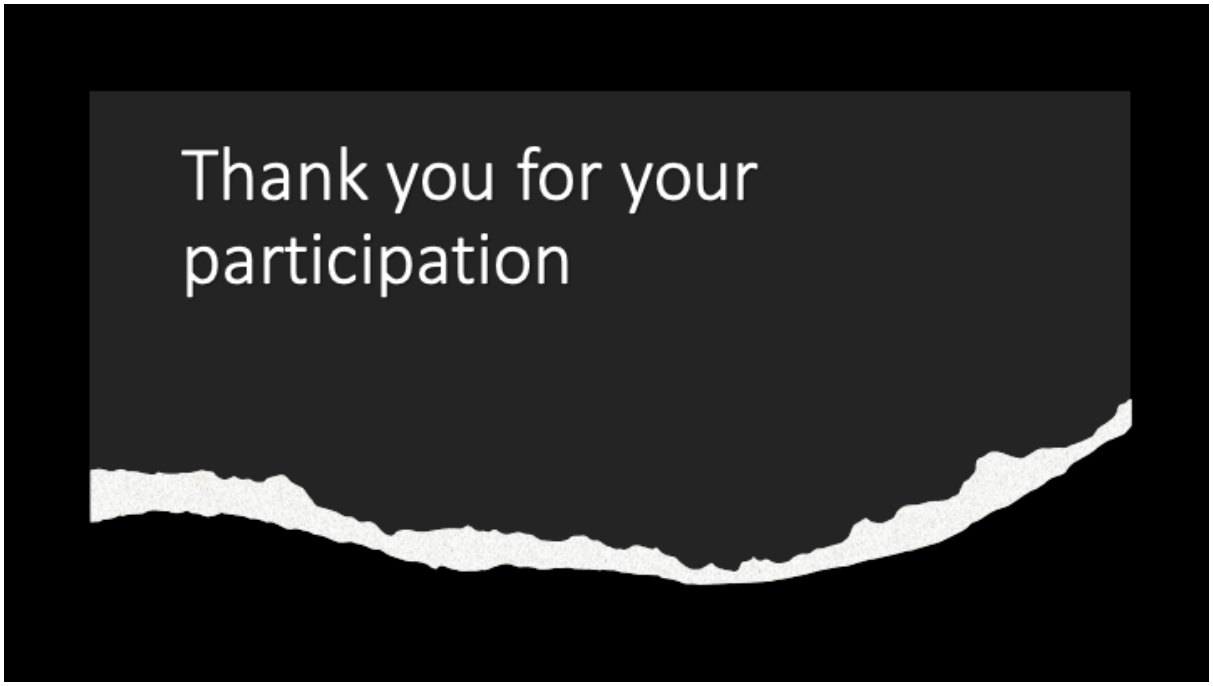
Slide 33

Section Nine


1
2
ring.com
3
Slide 34


1
2
ring.com
3
Slide 35


1
2
ring.com
3
Slide 36


Thank you for your
participation

Appendix G – Placement of the Ring Video Doorbells

Appendix H – Photographs of the Driveway

Appendix I – Photo of the Car and Number Plate

Appendix J – Photo of Blue Hooded Sweatshirt

Appendix K – First Preliminary Research Still Images

2 Metres

3 Metres

4 Metres

5 Metres

6 Metres

7 Metres

2 Metres

3 Metres

4 Metres

5 Metres

6 Metres

7 Metres

Appendix L – Second Preliminary Research Still Images

2 Metres

3 Metres

4 Metres

5 Metres

6 Metres

7 Metres

2 Metres

3 Metres

4 Metres

5 Metres

6 Metres

7 Metres

2 Metres

3 Metres

4 Metres

5 Metres

6 Metres

7 Metres

2 Metres

3 Metres

4 Metres

5 Metres

6 Metres

7 Metres

Appendix M – Photo of Black Sweatshirt

Appendix N – Photo of White T-Shirt

Appendix O – Raw Data from Participant Group 1 and 2.

- https://staffsuniversity-my.sharepoint.com/:x:/g/personal/c012690l_student_staffs_ac_uk/ETxbrElv2w9DgapsHQ5XJzMBl6xUR1qGOVkHt1QxdiSiSQ?e=R9wzZ1

Appendix P – Participant Group 1 and 2's Answers to:

"Can you identify any letters or numbers from the number plate?"

"Can you identify any branding?"

- https://staffsuniversity-my.sharepoint.com/:x:/r/personal/c012690l_student_staffs_ac_uk/Documents/THIRD%20YEAR/RESEARCH%20PROJECT/Letters-Numbers-Branding.xlsx?d=w4bbaa43bd87b41e2bbb102ba6f45457f&csf=1&web=1&e=kn9N1