An experimental investigation: The effects of familiarity and lighting on face recognition accuracy.

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Abstract

Face recognition often plays an important role in identification in many forensic settings as well as other commercial settings. Despite its prevalence, eyewitness memory and identification are highly error prone. Many factors can influence face recognition accuracy under a variety of different conditions. The aim of this research is to explore the influence of familiarity and lighting to accurately identify the correct face from CCVT footage in an experimental recognition memory task. Results found a large effect of familiarity in all responses where familiar targets were correctly identified more often than unfamiliar targets**.** Results found no significant differences between the lighting conditions, which may suggest that lighting has little to no effect on accuracy of identification in this task. Further analysis found that participants were better able to discriminate familiar faces from the distractor faces in line-ups compared to unfamiliar faces. It also found that familiarity or lighting did not appear to bias observers to make incorrect decisions. It can be concluded that a familiarity advantage is consistent across viewing conditions, suggesting that familiar faces provide the most accurate identification responses. This can effectively be explained by sensitivity as a significant difference was again found for familiarity. It is also concluded that it is not possible to fully determine the influence of lighting on face recognition accuracy from this study alone. No clear bias was found between conditions, which suggests that the familiarity and lighting have no impact of the likeliness of choice in this sample.

Key words:	Face recognition	CCTV	Identification	Familiarity	Lighting

Introduction

Face perception is the understanding and interpretation of a face while recognition is the ability to correctly identify a person. Face recognition has been researched over many years and can be explained by the perceptual process of identifying patterns and discriminating the tones and depth of a face, usually by becoming more familiar with it (Bruce & Young, 1998). Facial recognition is believed by many to be a natural ability and is a widely accepted form of identification within today's society. This often plays an important role in identification in many forensic settings, as well as other commercial settings such as security and the purchasing of age prohibited goods. Despite its prevalence, it has been found on numerous occasions, that eyewitness memory and identification are highly error prone (The innocence project, 2013), which suggests that human face perception can be flawed. Research has found many different factors that can influence face recognition and identification accuracy; these include familiarity and illumination. These two factors have been extensively researched; however, little is known about the effect they have in relation to real life settings and surveillance.

Surveillance systems are becoming more common in both private and public areas and closed-circuit television (CCTV) often plays an important role in practical settings when identifying a person of interest. It is therefore important to understand face recognition and identification to surveillance footage, to allow this process to be carried out in the most efficient way. Once a face has been recorded by CCTV, it would be reasonable to assume that it is easy to match that to a suspect; however, research has found this to be more complex and many factors may have an influence on accuracy. For example, lighting conditions are an important factor that should be considered alongside familiarity. This research will be discussed, and the aim of this study will be put forward in attempt to build on pervious literature in face recognition.

Familiarity

It is a common belief that, as humans, face recognition is a skill that we are experienced and competent at, however this may only apply to those who are familiar to us. Familiarity has been researched thoroughly in face recognition literature and it has been consistently found that those who are familiar with the targets tend to perform significantly better than those who are unfamiliar with the targets (Bruce, Henderson, Newman & Burton, 2001; Bruce, 1982; Ritchie, Smith, Jenkin, Bindemann, White & Burton, 2015). Familiarity can be studied in two different ways, which both have different practical implications. Recognition memory tasks rely on an individuals' memory of a face at a particular time, then asks them to choose the individual from a line-up. This can be related directly to an eyewitness of a crime, and research in this area gives a better understanding of the factors that can affect this. Matching tasks allow the viewer to make comparisons between two images or people that are presented simultaneously. This may seem more advantageous to viewers carrying out the task, as they do not need to rely on memory; however, Megreya and Burton (2008) found no differences in performance between the recognition memory and matching tasks. This provides support of the familiarity effect in both tasks, suggesting that familiar faces are both matched and remembered better than unfamiliar faces. Although performance in these tasks are comparable, Megreya and Burton's (2008) study did not consider any other factors such as, viewing or encoding conditions, therefore results may not be entirely transferable between tasks. The familiarity effect has been extended from memory tasks and photo-to-photo tasks, to photo-to-live-person tasks (ID checking) (Megreya & Burton, 2008). The effect has more recently been extended to passport officers, whose job it is to match faces to photos (White, Kemp, Jenkins, Matheson & Burton, 2014). This suggest that even experts in the field can still make face matching errors, which in turn could have negative effects in a real-life setting such as, boarder security and commercial settings. This has highlighted the problems with unfamiliar face recognition abilities in applied settings suggesting that more extensive research is needed in this area to understand why and under what conditions incorrect identification occurs.

Burton, Wilson, Cowan and Bruce (1999) carried out an experiment using a recognition memory task. They found that familiar face recognition is still significantly more accurate than unfamiliar, even under reduced viewing conditions (i.e. surveillance footage). In this experiment, they used university lecturers as targets and students from their department as familiar participants, while student's out-with that department were grouped as unfamiliar participants. The sample of participants may be problematic as some of the students who were grouped as unfamiliar may have seen the targets around campus and had some level of familiarity that was unknown to the researchers. Though this study provides important findings and supports previous research, more measures could have been carried out to better distinguish between the familiar and unfamiliar groups such as, asking participants if they were familiar with the targets. Surprisingly, Burton, White and McNeill (2010) found that when viewing conditions were optimal, unfamiliar face recognition did not improve. Viewers in this task where asked if pairs of the same face, were the same or different when presented simultaneously. In this study, the two images were taken of the same person, in the same pose with a high-quality camera, only a few minutes apart. These conditions appear to be optimal; however, it was found that errors still occurred 20% of the time. This suggests that even under optimal conditions, face-matching errors are relatively high for unfamiliar targets. These results have been replicated in many ways, which have been extended to practical settings where a person is asked to match a photo or a video to a live person (Davis & Valentine, 2009; Kemp, Towell & Pike, 1997), and in memory tasks that can be related to eyewitness identification (Burton et al., 1999). It has been suggested that this may be due to the variability of images and how familiar and unfamiliar faces are processed in different ways.

Theory and variability

It has been suggested for many years that familiar and unfamiliar faces are processed differently. The Bruce and Young (1986) model of facial recognition suggests that familiar face recognition is based on semantic codes that are specific to that individual, which suggests that we might have a clearer representation of a familiar person as a whole (Burton, Jenkins & Schweinberger, 2011). Unfamiliar faces are bound more closely to the visual details of one specific image (Hancock, Bruce & Burton, 2000), resulting in poorer discrimination between different pictures of the same individuals and images of similar individuals.

This model of face recognition effectively explains findings by Jenkins, White, Van Montfort and Burton (2011). They found that when participants were shown 20 images containing two identities and asked to organise into groups of the same people, they came up with, on average, nine different groups for unfamiliar identities. However, when the faces were familiar to viewers, they could accurately identify them into two groups. This suggests that familiarity mediates performance in this task and highlights the significance of within-person variability in unfamiliar identification. This directly supports the Bruce and young model in that the more visual representations an individual has seen of a person (i.e. the more familiar they are), the more accurate they will be when identifying them. More recent research has discovered similar findings in that when learning a face, individuals show better performance when the face is learned in high variability than low variability conditions (Ritchie & Burton, 2017), suggesting that exposure to naturally fluctuating instances of the same parson can enhance learning of the new identity. This study suggests that although unfamiliar face recognition may be largely image specific, faces can be learned through viewing various images of that person under different conditions. In this study, and many others in this area, they used celebrities from the UK as familiar faces and celebrities from Australia as unfamiliar faces. This may be problematic, and not a valid measure of familiarity as some may be unfamiliar with some of the UK celebrities and others may be familiar with some Australian celebrities. More often than not, people are only familiar with images of such celebrities and have never encountered their face in naturally varying conditions. This could mean that familiar faces that are viewed naturally and often (i.e. family members) may have a different level of familiarity than to celebrities. In the context of Bruce and Young's (1986) model, it could be argued that familiarity with celebrities, differ with personally familiar people as they may rely on certain visual pictorial cues that allow them to be recognised. Contrastingly, personally familiar faces could be recognised any circumstance. More research by Armann, Jenkins and Burton (2016) has found an advantage for unfamiliar faces in a memory task that was image-specific. Results show that viewers were more accurately able recognise if they had viewed a particular image of an unfamiliar face, compared to recognising if they had previously viewed a particular image of a familiar face. These results are supportive of Bruce and Youngs (1986) model of face recognition as viewers would be relying on one representation of a face that was viewed previously so will be looking for specific visual cues rather than focusing on a person. This would also suggest that we have poorer memory of specific pictorial details for familiar faces, compared to unfamiliar faces.

As we encounter individuals in a range of different viewing conditions, they become more familiar to us as we have seen a variety of different viewing points of both their face and body. In many cases, we meet and familiarise ourselves with their identity in motion and can subsequently recognise them in a variety of different visual conditions. It has been suggested that the reason familiar people may be better identified is due to the movement that can be seen. Roark, O'Toole, Abdi and Barrett (2006) found that when individuals were presented with moving faces, they were more accurate at identifying the target than when presented with static faces. This study used previously unfamiliar faces, which provides useful insight into how a face may become more familiar; however, it may not be a valid representation of 'familiar' face recognition according to the Bruce and Young model (1986). It has, however, been found that the familiarity advantage is largely dependent on the face, rather than recognition of any other cue, for example; body, gait, shape or clothing (Burton et al., 1999). This suggests that if one can gather information about the idiosyncratic ways in which a face may change through movement, it may lead to a more generalisable representation of the person and better able them to be recognised (Bruce & Young 1986). O'Toole et al. (2011) later concluded that still images encourage reliance on the face for recognition; however, in moving images the attention is directed more equally across face and body. This may be advantageous to witnesses when they are viewing images or footage of a crime. Viewing a moving video of a target or suspect may aid in recognising an individual as a whole, rather than just viewing an image of their face. This would be especially important in conditions that may obscure important features of the face such as illumination, which can cause shadows.

Lighting

As it has been established that familiar face recognition is relatively unaffected by varying conditions, much of the research has focused on pose and differences in images viewed by the observers. Illumination, or lighting, is another important factor when considering identification accuracy as changes in illumination from one image to another can have significant effects on performance in matching tasks (Tarr, Georghiades & Jackson, 2008; Liu, Bhuiyan, Ward, & Sui, 2009). Research into lighting differences affecting face perception have found some interesting results that should be considered in more practical settings. When a 3D face is projected as a 2D image, through photo or video, it determines which surfaces and shadows are visible to the viewer. The perception of the face will ultimately be based on the viewers' interpretation of the lighting variations (Kemp, Pike, White, & Musselman, 1996; Liu, Collin, Burton, & Chaudhuri, 1999). In natural conditions where crimes may take place, a perpetrators face can be illuminated in many different ways depending on the time of day and their location. It has been found that lighting direction can cause shading that can hide important parts of the face, which can be essential when perceiving an unfamiliar face (Ellis, Shepard & Davies, 1979). Braje, Kersten, Tarr and Troje (1998) found that when participants learned a face in one illumination condition, performance declined for novel illumination conditions suggesting that unfamiliar facial recognition processes are susceptible to the direction of light, or the shadows that the light creates, making the face look different. In theory, the face then appears as an unfamiliar variation of that identity. This finding again would support the Bruce and Young (1968) model, as unfamiliar faces rely on a memory of an image in one variation, making it difficult to recognise it as the same identity. This study only used faces that were unfamiliar to participants, so no differences were accounted for between familiar and unfamiliar faces. A more recent study by Favelle, Hill and Claes (2017), found that there was no effect of lighting for faces viewed from above meaning that the camera capturing the face from above with in-front-of-face lighting, did not affect identification accuracy. However, in this study the stimuli were illuminated from an in-front-of-face source, which cannot be generalised to practical settings as natural light sources are rarely in front of face. They also used synthetic faces created by a computer, which may reduce the efficiency of processing suggesting that it is not a valid measure of real face recognition performance. Unlike real faces, synthetic faces are symmetrical and lack surface texture, so the impact of lighting would be reduced in comparison with real life. This study does highlight the importance of lighting and viewpoint mediating face perception however their results cannot be generalised to a practical setting as they lack ecological validity.

When identifying a face from CCTV footage the light source is typically coming from above which has been found to be advantageous to face perception (Hill & Bruce, 1993; Hill & Bruce 1996). Camera angle is also typically coming from an above view, looking down on the target and it has been found that this has no disadvantage on identification accuracy (Favelle, Hill & Claes, 2017). Favelle et al., (2017) findings suggest that top lighting can be beneficial when the head is rotated upward, however people would rarely be looking up, in the direction of the camera in a real-life setting.

Although these findings do suggest that top lighting and an above camera source may benefit accuracy performance, these variables have not been investigated together, or in a more realistic setting. This is surprising as most CCTV cameras are located from above as with the direction of lighting, making it simple to predict potential difficulties and to re-create these conditions for study. Though face recognition has been researched using CCTV, the literature is very outdated and little research has investigated these effects in surveillance and the conditions that affect face identification in more modern, applied settings. As aforementioned, artificial faces and lighting are often used in these studies with very unrealistic viewing points. This has highlighted important implications for future research but implies little on real face identification in practice. Surveillance systems are often implemented with little understanding of the effects of lighting or viewing angle in relation to facial recognition ultimately making identifying a person more difficult especially if they are unfamiliar. This promotes practical problems in forensic settings, which should be studied more thoroughly.

Target Presence

An outstanding number of misidentifications have been made by eyewitnesses and it is often assumed that it is because the witness had a weak memory of the face. However, it has been found that many factors can influence ones' decision to choose a face from a line-up. A factor that can affect accurate identification is whether the target is present or absent in the line-up. It has been found that when individuals are told that the line-up may or may not contain the target, they are less likely to choose any of the targets and opt for a 'no match' option (Brewer & Wells, 2006). Associations between the types of responses have been found by Megreya and Burton (2007), where those who misidentified a face in target present conditions, were also likely to choose the wrong face in the target absent conditions, suggesting a bias towards choosing any face that is similar to the target. This is in line with Wells (1993) who found that if a target was absent from the line-up; individuals were more likely to pick a foil or second-best option than a 'no match'. This suggests that individuals tend to lower their criterion when the target is unfamiliar to them in absent conditions. Contrastingly, in familiar conditions, there was a straightforward association between the ability to correctly identify and correctly reject foils, which also supports the familiarity advantage. This has major implications in real life settings where line-ups are used to identify a suspect from witness memory. If they are unfamiliar with the suspect then they may be more susceptible misidentifying an innocent person who looks similar to the suspect, than if they were familiar with the suspect. It is therefore important to understand why and in what conditions errors in face recognition memory occur.

Current research hypotheses

Based on previous research it is clear that there is a significant difference between familiar and unfamiliar face recognition in both memory and matching tasks. Research into natural lighting conditions in which a face may be captured for practical identification purposes is limited; however, important results have been found. Many changes are underway to improve street lighting in the cities resulting in new LED lights being implemented in the hope to reduce crime and enhance visibility in a more environmentally friendly way (Edinburgh City Council, 2019). The present study has taken this information on board and created an experiment that mimics typical lighting conditions under which a face may be captured by CCTV footage. The aim of this research is to explore the influence of familiarity and lighting to accurately identifying the correct face from CCVT footage. CCTV plays an important role in practical tasks in identifying people such as, a person of interest or even a person who has committed a crime. The findings of this project may be useful in criminal investigations, as it has been highlighted that many misjudgements are made in facial recognition. A better understanding of the effects of accuracy mediated by lighting and familiarity may help decrease inaccuracies in matching performance in real life settings.

After reviewing the literature, it has led the researcher to speculate that these conditions will have limited influence over familiar face recognition in comparison to unfamiliar face recognition. Based on previous findings, it is expected that;

1. Accuracy for familiar faces will be higher than unfamiliar faces.
2. Accuracy will be lower for streetlight condition compared to artificial light and daylight conditions.
3. There will be no interaction between familiarity and lighting.

4. Signal detection measures of sensitivity will be enhanced for familiar faces compared to unfamiliar faces.
5. Signal detection measures of sensitivity will be enhanced for the daylight condition, compared to internal artificial and streetlight conditions.
6. No interaction will be found between familiarity and lighting on measures of sensitivity.

Method

Design

A within-subjects, repeated measures design was adopted, as all participants contributed data to each of the experimental conditions to identify differences between them. The design had three factors that were manipulated; familiarity had two levels, familiar and unfamiliar. Lighting had three levels, daylight, internal artificial light and streetlight. Target presence had two levels, target present and target absent. Face recognition accuracy was the subject of interest, which had five possible variations; hit, miss, incorrect ID, false ID and correct rejection. A hit is where a target was correctly identified in a target present condition. A miss is where the no match option was chosen in a target present condition. Incorrect identification is where the wrong face was chosen in the target present condition. False identification is where a face was chosen in a target absent condition and lastly, correct rejection is where no match option was chosen in target absent condition. These variables produced four two-way analysis of variance (ANOVA) to explore the impact of familiarity and lighting on the dependent variables (i.e. hit, miss, incorrect ID, and correct rejection). An ANOVA was not carried out for false ID, because it is the reverse of correct rejection as these were both target absent conditions. Signal detection analysis was then carried out to determine whether responses were mediated by sensitivity to the image properties or biased to select or to reject the line-up arrays.

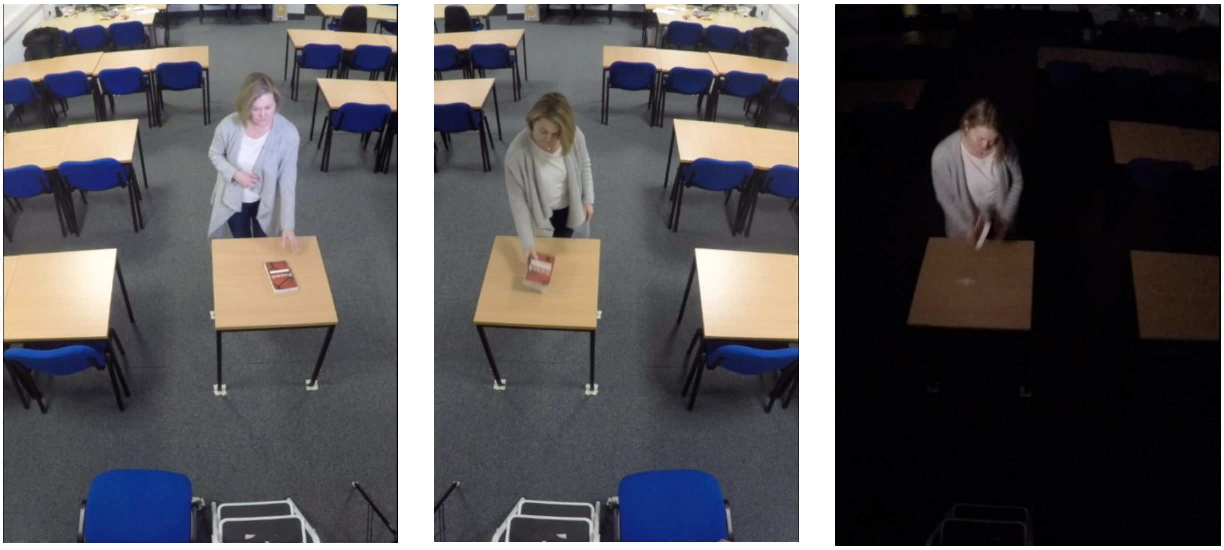
Participants

All 44 participants were students of Psychology or Psychology & Sociology at Edinburgh Napier University. All participants had normal or corrected to normal vision and were over the age of 18. Participants were recruited to take part in the online experiment through opportunity sampling, where an advert was displayed through participant pool at Edinburgh Napier University. A poster was also displayed on the recruitment notice board located at Edinburgh Napier Sighthill campus where details were available on how to sign up.

Materials/apparatus

To gather the stimulus set, twenty-four targets were recruited. Twelve of these individuals were teaching staff from Edinburgh Napier University (ENU) psychology and sociology departments and the other twelve individuals were from out-with the university. The researcher chose these people as the targets as all experimental participants were Psychology/Psychology & Sociology students from ENU so the teaching staff from those courses would be personally familiar to them. Those recruited from out with the university should be unfamiliar to them. This was also controlled for in the experiment where participants were asked if each target was, or was not, familiar to them. Staff from the psychology/sociology modules were emailed asking them to participate to help gather materials for the project. A social media advert was posted by the researcher to recruit the twelve participants out with the university.

A GoPro HERO4 camera was used to capture each actor; this was mounted onto a wall at 254cm from the ground. The ‘internal artificial light’ condition was under typical office lighting within ENU. An LED light (NanGuang CN-600HS) was used in addition to the standard lighting in the room, which was typical office lighting, to create the ‘daylight’ condition. This was measured at 250lux, which is comparable with typical outdoor daylight measured using a light metre (URCERI MT912). A ‘streetlight’ condition was created using the LED light alone, measured at 10lux (an example of all lighting conditions can be seen in figure 1). These measurements were in accordance with information found on Edinburgh City council website about street lighting and lux measurements (Edinburgh City Council, 2019).



A B C

Figure 1: Screen shots of the three lighting conditions. A is the daylight condition; B is internal artificial light condition and C is the streetlight condition.

Targets were then taken elsewhere in the university to have their photograph taken by a digital camera (Sony Handycam), in attempt to alter the lighting condition and surroundings. They were asked to change their appearance slightly to see a variation in their appearance this can be seen from the highlighted face in figure 2 compared to figure 1. This target simply restyled their hair and covered the clothes worn in the video. A table with a book on it and a chair with a jacket on it were placed in the room about 1 ft from the wall with the camera on it. Actors were asked to follow a script which allowed their face to been seen by the camera from a variety of angles and distances. All video footage was edited and displayed in the same way for each condition with a resolution of 750p (figure 1).

Two, six-person line-ups were created for each target; one with the target present and one with the target absent. The Psychological Image Collection at University of Stirling (PICS) and The Karolinska Directed Emotional Faces (KDEF) database (Lundqvist, Flykt, & Öhman, 1998) were used alongside the pictures taken by the researcher to create the simultaneous line-ups where the non-target faces were matched to targets through visual similarity. The pictures were edited to size 200 w x 270 h pixels and an example of a target present line-up can be seen in figure 2, while figure 3 shows a target absent line-up.

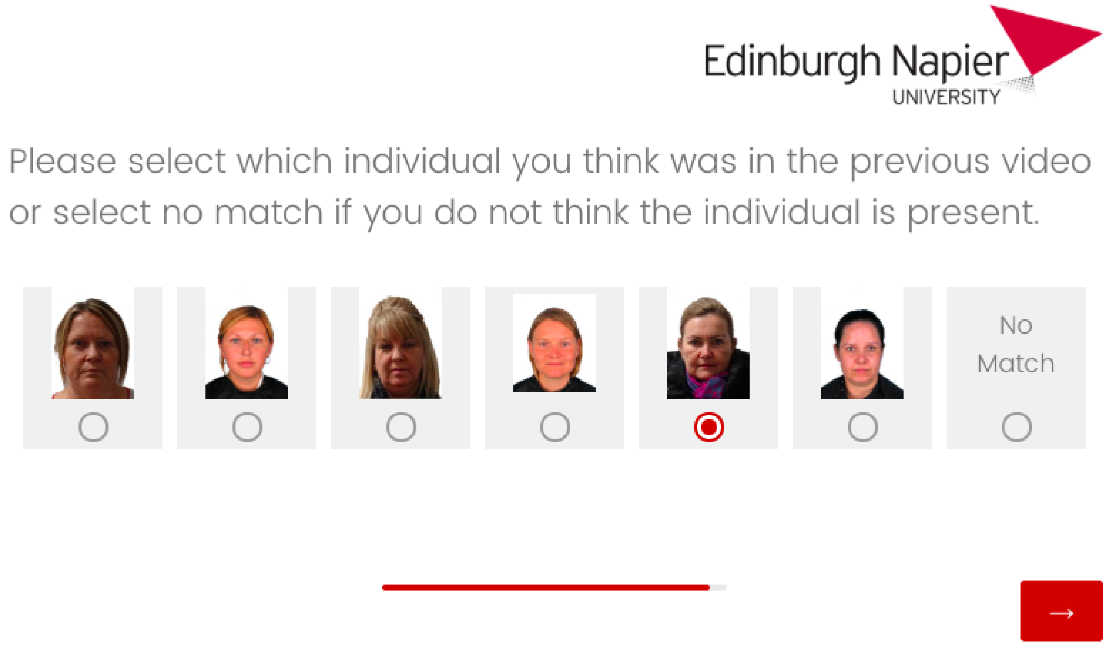


Figure 2: Simultaneous target present line-up for target (highlighted by red button) depicted in figure 1.

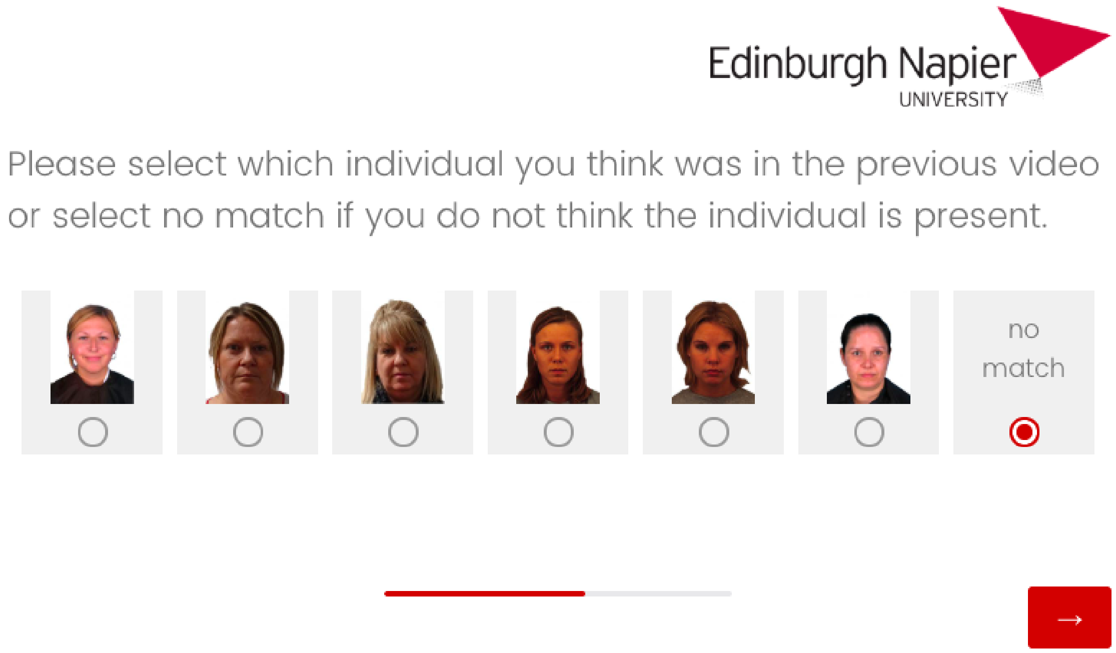


Figure 3: Simultaneous target absent line-up for target depicted in figure 1.

The data processor Qualtrics was used which enabled participants to take part online and all responses were recorded. All conditions were equally randomised for each participant, so they viewed each target once and each lighting condition eight times. They would be shown one of two line-ups per target; however, this was unable to be equally randomised meaning that some participants viewed more target present/target absent conditions than others.

Procedure

Participants took part online where they were first shown an information sheet containing details of the experiment. After reading, they were asked if they would like to continue. If participants clicked 'yes', then they would be presented with a layered privacy notice informing them of how their data would be used. If participants clicked 'no', then they would be taken to the end of the experiment and thanked for their interest. After reading the privacy notice they were asked if they consent to taking part in the project. At this point, they are reminded that they can terminate the experiment at any time simply by closing their browser. If they clicked 'no', again they would be taken to the end of the experiment and if they clicked 'yes', then they would be shown instructions on the next page, then the first trial would be displayed. For each trial, participants were asked to watch the video clip on the screen only once, and then were asked to click next to move on. They were then asked if the individual shown in the previous clip was familiar to them, which they had to click 'yes' or 'no' then asked to click next. They were then presented with a six-person simultaneous line-up and asked to click the individual whom they thought was shown in the video, or there was a seventh option of 'no match' if they did not believe the person was present. Once the participants had chosen an option, they clicked next which took them to the next trial where that whole sequence was repeated so that each participant viewed 24 trials each with a different target. Once all 24 trials were complete, participants were presented with a debrief and asked for secondary consent to ensure they allowed the researcher to use their data. Lastly, they were presented with a message that thanked them for taking part.

Ethics

There are no known risks to participants as all experimental stimuli is of a completely neutral nature however, participants were reminded that they could terminate their participation at any time without reason simply by closing their browser. Experimental participants were unable to withdraw from the study after completing the experiment, as all data was anonymised, and it would not be possible.

Results

Results were obtained through the data processor Qualtrics. Data were collated by organising into a spreadsheet where total score for each response (hit, miss, incorrect ID, false IF and correct rejection) were calculated for each condition (two familiarity and three streetlight). These were then transformed into percentages of how many responses were given, out of a total of how many responses they viewed in either target present or target absent condition. Due to the limited number of trials and unequal randomisation, some participants did not view some of the conditions. For these trials, a series mean value was calculated in order to complete the data set. Results were analysed in two different ways. First accuracy was explored in relation to the target present and target absent trials. This generated four repeated measures ANOVA's. Signal-detection analysis was then carried out with target present hit rates and target absent false ID rates. This was to determine whether the responses were driven by sensitivity to familiar faces or a more liberal response bias to make inaccurate identifications.

Descriptive Statistics

Before results were analysed, descriptive statistics were explored. Figure 4 shows clearly that in the correct conditions mean percentage of responses were higher for familiar faces than unfamiliar faces, and for the incorrect responses it can be seen that familiar faces had a lower mean percentage of response. There seems to be no trend in differences between the lighting conditions from this bar chart however, inferential statistics will explore this further.

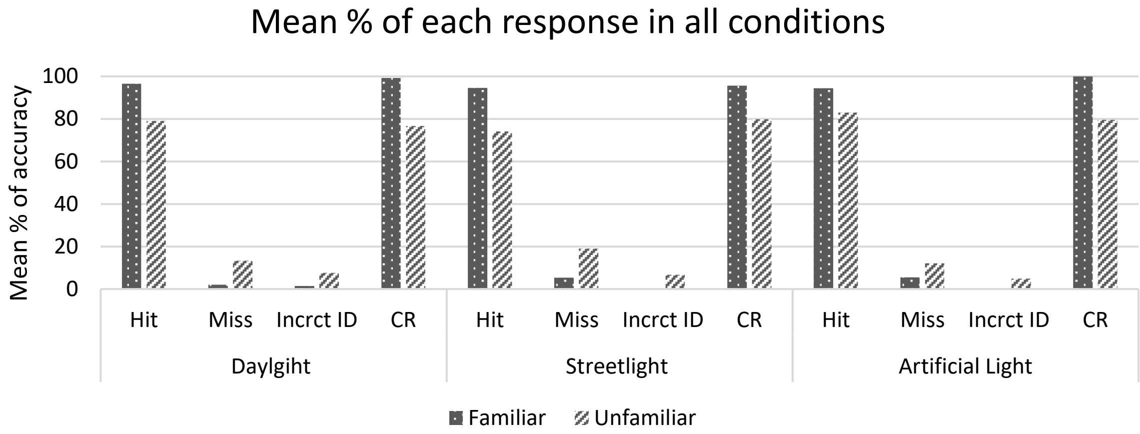


Figure 4: Bar chart displaying mean percentages of responses (hit, miss, incorrect ID and correct rejection) in daylight, streetlight and internal artificial light conditions, for both familiar and unfamiliar targets.

Inferential Statistics

Accuracy

Four separate AVNOA's (analysis of variance) were carried out in order to see if there were any significant differences between the three lighting conditions and whether this was mediated by familiarity.

The first ANOVA was carried out to establish any differences between the two familiarity conditions and the three lighting conditions based on the mean hit responses, which was where targets were correctly identified in target present conditions; this can be seen more clearly in figure 5. The results found no significant main effect of lighting (*p*= .40). A large significant main effect was found for familiarity F (1, 43) 27.5, p = <.001, n^2p = .39, but no significant interaction was found between familiarity and lighting (*p* = .36). The ANOVA found that the mean percentage of hits for familiar faces (*M* = 95.2) was significantly higher (*p* = >.001) than for unfamiliar faces (*M* = 78.8). This suggests that familiar faces will be associated with increased rates of identification irrespective of lighting.

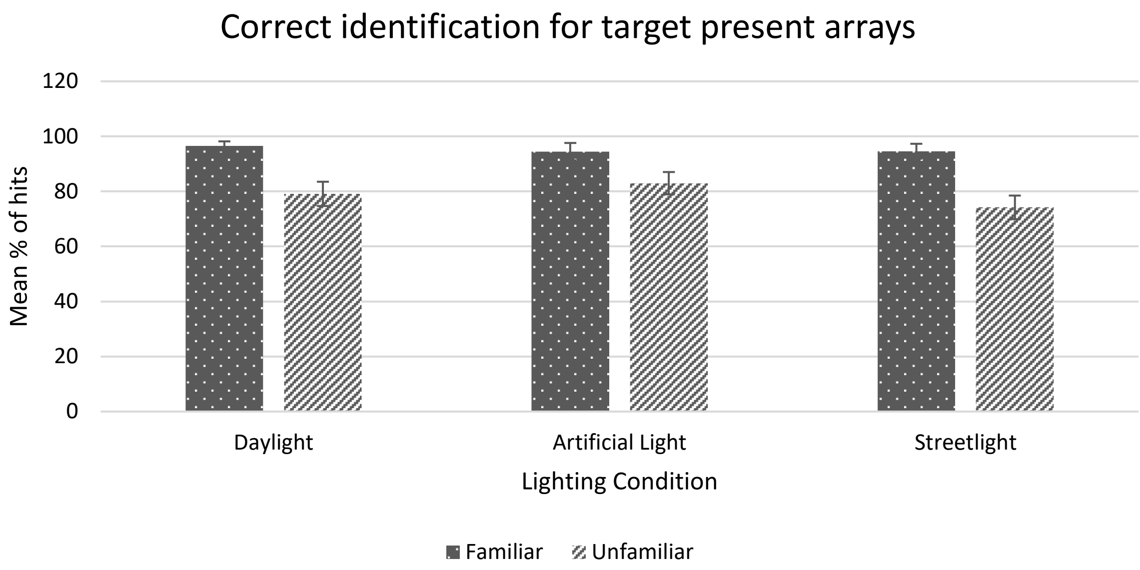


Figure 5: Bar chart displaying average percentages of correct identification (hit) responses for familiarity and lighting in target absent conditions. Error bars represent standard error of the mean.

The second ANOVA was carried out to establish any differences between the two familiarity conditions and the three lighting conditions based on the mean percentage of miss responses. This was where the target was present in the line-up, but the participants opted for the 'no match' option. Results can be seen more clearly in figure 6. No significant main effect was found for lighting (p = .26). A large significant main effect was found for familiarity F (1, 43) 17.7, p = <.001, n^2p = .29, but no significant interaction was found between familiarity and lighting (p = .42). The results found that the mean percentage of missed targets for familiar faces (M= 4.35) was significantly lower (p = <.001) than unfamiliar faces (M = 14.9). This means that, unfamiliar targets were associated with missing targets from target present line-ups more than unfamiliar targets. As seen in figure 6, miss responses appear to occur more often for unfamiliar faces in the streetlight condition, and less often for familiar faces in the daylight condition. The effects were not significant but could indicate a lack of power in the design.

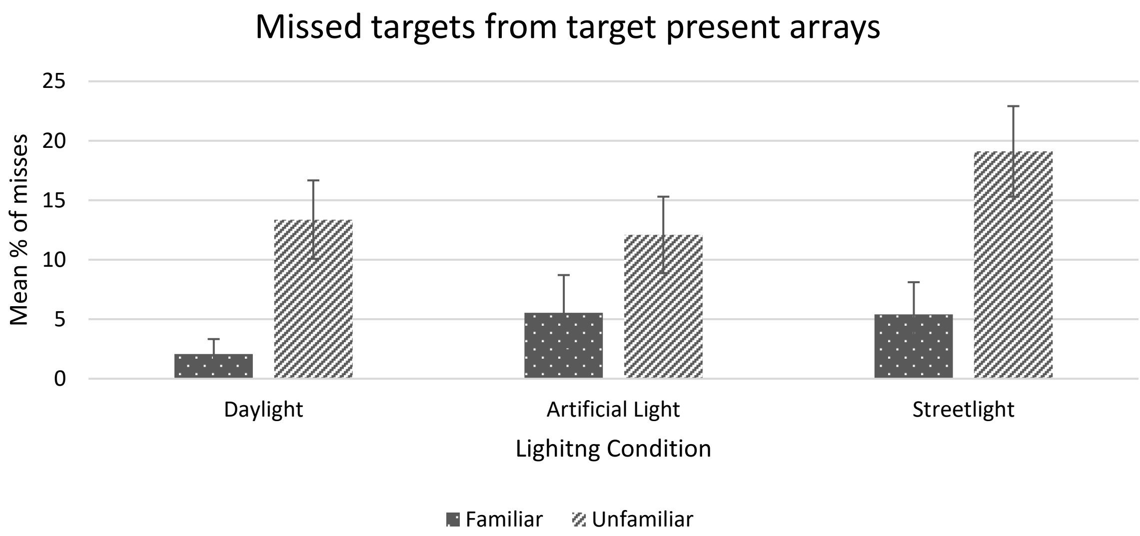


Figure 6: Bar chart displaying average percentages of missed targets from the target present condition (miss) for familiarity and lighting. Error bars represent standard error of the mean.

Another within subject's ANOVA was carried out to establish differences between the conditions based on the mean incorrect identification responses from the target present arrays. Results can be seen in figure 7 where no significant main effect was found for lighting (p = .41). A large significant main effect was found for familiarity F (1, 43) 13.7, p =.001, n^2p = .24, but no significant interaction was found between familiarity and lighting (p = .78). The mean percentage of familiar faces (M = .46) that were incorrectly identified was significantly lower (p =.001) than the mean percentage of unfamiliar faces (M = 6.39) that were incorrectly identified. These results suggest that, participants were significantly more likely to incorrectly identify a foil from the target present line-up array if the target was unfamiliar to them, irrespective of lighting.

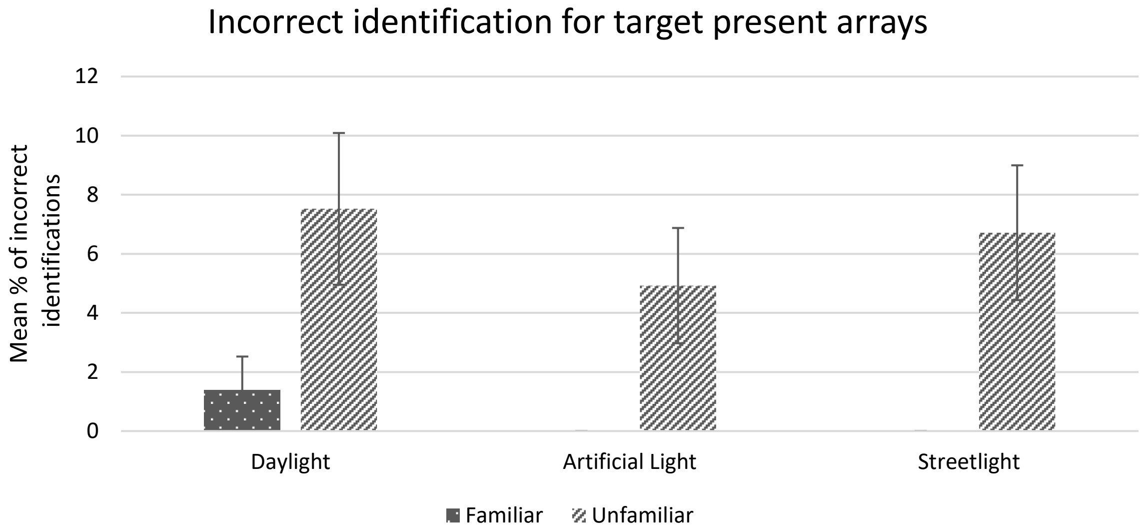


Figure 7: Bar chart displaying average percentages of incorrect identification responses for familiarity and lighting. Error bars represent standard error of the means.

A final ANOVA was carried out to establish any differences between conditions based on the mean correct rejection responses. This was where the target was not present in the line-up and the participants correctly rejected the foils, opting for 'no match'. These results can be seen in figure 8. No significant main effect was found for lighting (p = .75) however, a large significant main effect was found for familiarity F (1, 43) 36.0, p = <.001, n^2p = .46. There was no significant interaction between familiarity and lighting based on correct rejection scores (p = .50). The mean correct rejection responses for familiar faces (M = 98.3) were significantly higher (p = <.001) than the mean correct rejection responses for unfamiliar faces (M = 78.7). These results indicate that, familiar faces will be associated with increased accuracy in rejecting a target absent line-up, irrespective of lighting.

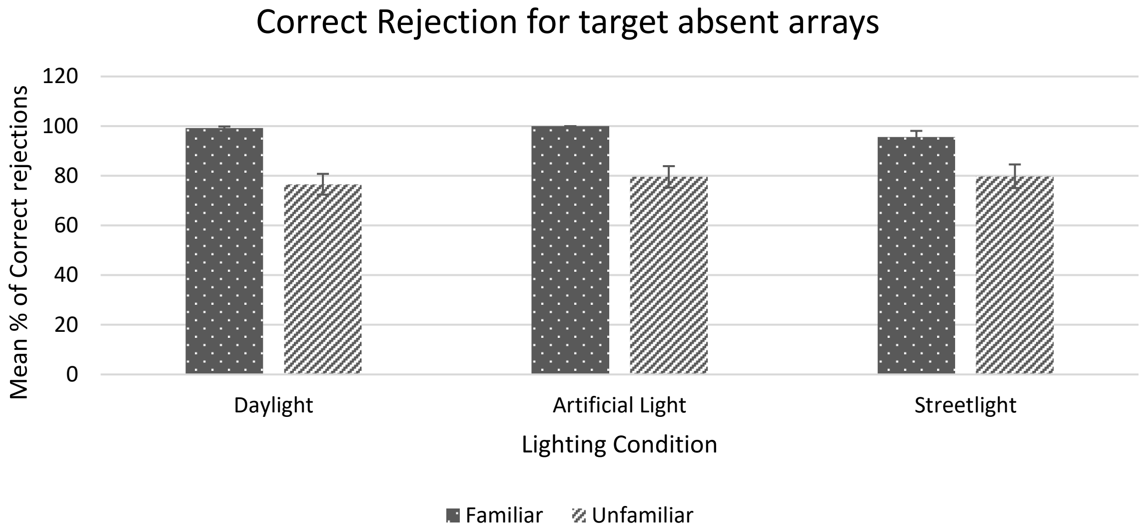


Figure 8: Bar chart displaying average percentage of accuracy for target present arrays that were correctly rejected (no match option was chosen) for familiarity and lighting. Error bars represent standard error of the mean.

Signal detection

Though pervious analysis shows the differences between the variables, it does not give any understanding of why these differences occur. Signal detection analysis is important to carry out as it determines whether the responses were driven by sensitivity to familiar faces or a more liberal response bias to make inaccurate identifications. Hits and false identification scores were combined to produce sensitivity and bias scores (Green & Swets, 1966). An analysis of variance was then carried out to investigate any differences between the two familiarity conditions and three lighting conditions based on both sensitivity and bias scores.

For sensitivity, there was no significant main effect of lighting (p = .35), however there was a large significant main effect for familiarity F (1, 43) 60.9, p = <.001, n^2p = .59. There was no significant interaction found between familiarity and lighting. The mean score for familiar faces (d' = 4.87) was significantly (p = <.001) higher than on unfamiliar faces (d' = 2.94) this can be seen in figure 6. These results suggest that participants who were familiar with the targets were more sensitive to discriminating between the foils in the line-ups, than unfamiliar targets.

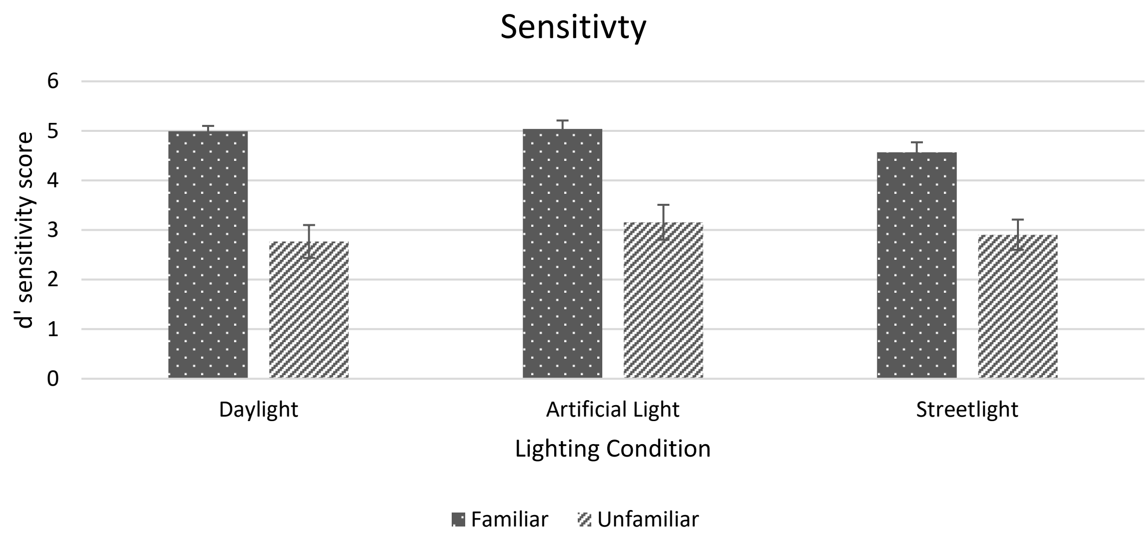


Figure 9: Bar chart displaying average sensitivity score for familiarity and lighting. Error bars represent standard error of mean d'.

For criterion, there was no significant main effect of familiarity (p = .084) or lighting (p =.68), and there was no significant interaction between them (p = .097). These results suggest that familiarity or lighting had no response bias to make inaccurate identifications.

Discussion

Summary of results

Results of both accurate and inaccurate responses showed a significant effect of familiarity. It can therefore be suggested that observers were significantly more likely to correctly respond if the target was familiar to them. This means that observers can more accurately identify a target who is present in a line-up, and correctly reject foils if they are familiar with the target. Results also suggests that observers were more likely to incorrectly miss or incorrectly identify a foil if the target was unfamiliar to them, meaning that unfamiliar faces will be associated with lower accuracy.

Results found no significant differences between the lighting conditions, ultimately suggesting that lighting has little to no effect on accuracy of identification. With that being said, a trend can be seen in figure 6 where unfamiliar have a higher miss response rate in the streetlight condition. Another slight trend can also be seen from figure 8 in that daylight and artificial light had no effect on performance whereas in the streetlight condition, performance was slightly lower. Though these trends can be seen in the bar charts, no significant statistical differences were found. Due to the time constraints of this project, the adequate sample size was unable to be recruited so, it can be suggested that significant differences between the lighting conditions may have been found if the sample was adequate to generate statistical power.

Results from signal detection analysis suggest that participants were better able to discriminate familiar faces from the foils among the line-ups. It also suggests that familiarity or lighting did not appear to bias observers to make incorrect decisions.

Interpretation

In relation to the expected outcomes, hypothesis 1 has been supported as participants correctly responded to familiar faces more accurately than unfamiliar faces. Familiar targets had an accuracy of 90% or above which is in line with much of the previous research in this area and provides support for the familiarity effect found in the majority of the face recognition literature, which dates back many years (e.g. Bruce, 1982; Bruce et al., 2001; Ritchie et al., 2015). The findings from the current research support this in relation to surveillance footage, which adds to the previous literature in a more ecologically valid way.

This result can be explained in many ways. Signal detection analysis suggests that this familiarity advantage is due to participants showing enhanced sensitivity for familiar faces, ultimately making them easier to discriminate between the foils, which supports hypothesis 4. This explains why there was a familiarity advantage across responses. This is in line with research stated previously (Bruce et al., 2001) which also found that discriminability was driven by familiarity. In relation to real life settings, this finding is important as it supports previous findings that suggest familiarity is important in improving identification accuracy, as the more familiar one is with the target, the better their ability of discriminating among foils. This may be explained by the amount of information given in the CCTV footage. Each video lasted around 30 seconds, which gave the participants time to match the face in the video to any visual memories they may have of that face. This would then obviate the need to recall the memory of the video to match it to the faces in line-up, as they already have a more abstract representation of them. If the face is unfamiliar, then they rely on their memory of the face from the CCTV footage and are subsequently less able to discriminate between the foils. This would support the Bruce and Young model (1986) in that familiar and unfamiliar faces are processed in different ways. It is these tasks that are more comparable to witness memory, which explains how it may be easy for misidentifications to be made.

It has been found that the encoding conditions a face is viewed in can have a direct effect on identification accuracy (Smith, Quigley-McBride, Wilford & Wells, 2019). The current findings, however, showed no significant differences found between the lighting conditions therefore hypothesis 2 is not supported. Based on previous findings from studies involving different lighting and viewing conditions it would have been expected that there would be enhanced sensitivity for daylight condition in comparison to artificial and streetlight. However, no significant differences found between the conditions resulting in hypothesis 5 not being supported. These findings were surprising as it was expected that the poorer lighting condition would have had a negative effect on correctly identifying or correctly rejecting a target, especially for those who were unfamiliar. Previous research found that changes in illumination resulted in large image variation, which is often larger than a change in identity (Adini, Moses & Ullman, 1997). This would suggest that the same face viewed under two different lighting conditions could look more different from two images of different identity. The present research findings do not support this as no differences in performance were found despite the variations in lighting and images that were displayed to the participants. This therefore might suggest that consideration of whether the lighting variation happens during encoding at the first viewing of the face or at retrieval at testing may be beneficial to the literature. The current research findings may be due to inadequate sampling, which increases the risk of type two error. These findings may also be due to a ceiling effect, which is where all participants' score near to perfect which suggests that the task was too easy for participants, particularly in the familiar conditions. If the task was more difficult, i.e. the streetlight condition was darker; the performance may not be as high. Nonetheless, the aim of this study was to replicate real-life lighting conditions, therefore by making the task more difficult, it would decrease the ecological validity, making it less realistic. The findings from this sample ultimately suggest that lighting conditions in this task have no significant effect on the number of incorrect identifications made by observers which has implications for future research and practice however, the results should be taken with caution as the sample size was inadequate. Results fail to reject hypotheses 3 and 6, as no interactions were found between the familiarity and lighting conditions in any of the responses.

Individual differences may have played a role in the findings of this research. An age bias has been found in much of the literature in face recognition suggesting that there is a greater reliability for same-age hits than other-age hits and that false alarms were less likely for those in the same age group in comparison to other-age groups (Rhodes & Anastasi, 2012). The differences in age between the students taking part in the experiment and the targets, could have affected the current studies results but this cannot be concluded, as age was not accounted for by the researchers. The aim of this study was to investigate a more realistic setting of face recognition conditions and in real life settings the person being identified and the person viewing the line-ups, may be of any age, therefore results with variations in age must be considered. Face recognition has been found to show age related increases in false identifications (Searcy, Bartlett, & Memon, 1999) which is relevant in the broader theoretical context.

Ageing affects different cognitive abilities and face recognition directly relates to fluid abilities (i.e. working memory, problem solving and decision-making in applied settings) which have been found to decline over time (Wiese, Komes, Tüttenberg, Leidinger, & Schweinberger, 2017). This highlights that age is an important factor to account for in future research to investigate individual differences such as age and gender. However, it is recognised that this would require a much larger sample and target set to reach statistical power.

The current research adds to our prior knowledge in this area as it has been established that there is a benefit of familiarity that allows for better discrimination for images of familiar faces. This study provides support for this familiarity advantage in realistic conditions. It is therefore important to understand that unfamiliar face recognition is flawed and around 20% of errors are likely to occur. These findings have implications for future research and practice, which will be addressed later. Firstly, there are some limitations of the current research that need to be considered.

Limitations

As with any research, there are some limitations to this study, which might have affected the results unintentionally. Firstly, the sample size was incomplete as this project was under time constraints, which may make the results less reliable. This may have affected the results, as the statistical power was too low for significant differences in the lighting conditions to show: if more participants were recruited, then results may have been vastly different. The researchers did not ask participants for any demographical information such as age and gender as these were not main factors that were being explored. However, if these were asked for, it could have provided some interesting results as differences in age (Rhodes & Anastasi, 2012) and gender (Weirich, Hoffmann, Meißner, Heinz & Bengner, 2011) have been found in facial recognition. This means that the current sample might also have been biased in a way that the researchers were unaware of. This ultimately makes it difficult to generalise the findings to a wider population.

There are some design problems that need to be addressed which could have affected the outcome of the results. The software that was used to run the experiment was unable to equally randomise all conditions. Each condition was randomised, but the line-up conditions were not equally sampled for each participant across conditions. This means that one participant may have seen 10 target present conditions and 14 target absent conditions, and so forth. It also would mean that some participants had seen most daylight conditions as target present and others had seen only 1 target absent in daylight. This in comparison to other research may cause reliability issues, so results should be taken with caution. Due to this software, the researcher was unable to limit the time allowed to watch each video, which some participants may have taken advantage of. Though there was an attempt to resolve this by adding instructions to only watch each video once, due to the uncontrolled environment, they may have watched it multiple times. This may have allowed some viewers to study the targets longer than other, which may initiate learning a process. With this software, it allowed participants to take part online, which means that the environment that the participants were in could not be controlled, so confounding variables are unaccounted for.

There were also some problems with the set-up of the experiment, which need to be highlighted for future research. Targets were matched as best as possible in age and gender to the distractor faces/foils used in the line-ups. However, due to time constraints of the project, visual similarity was not always achieved, meaning that some of the targets looked dissimilar to others in the line-ups, which may have allowed the observer to correctly identify the target more easily, especially for unfamiliar targets. Targets and distractor faces were also used multiple times in different line-ups which may have initiated a learning process, making some previously unfamiliar faces more familiar (Mäntylä, T., & Cornoldi, 2002). This is endemic within face perception research and the effects should be taken into consideration. The cameras used to film targets were not typical surveillance cameras, which may have meant the quality was too high resulting in the task again, being easier to perform (Keval & Sasee, 2008). Another issue may have been that the daylight and artificial lighting conditions were too similar. As seen in figure 1, the daylight and artificial light conditions look fairly similar, despite their difference of 165 lux. It can be argued that the daylight condition is much brighter and therefore shows less shadow on the face, making it more visible to the viewer. As found by Ellis et al., (1979) often shadows can obscure important parts of a face which may prevent accurate identification. This is why it may be important to re-create these conditions in a more controlled environment with a larger sample to see if these conditions still show no difference.

The chosen method of analysis may have found different results than other methods, which should be taken into consideration. Due to experimental design problems, imputation for missing data was used to fill in the blank trials. This may have affected the results, as it would not be a true score for that trial however, this step was crucial to enable data to be analysed. It is recognised by the researcher that the data was unbalanced so any method of analysis may have been compromised.

Implications

The findings from this research provide substantial and valuable implications for both future research and practice. Firstly, the findings highlight that the familiarity effect is still evident when using more realistic conditions than previously used. Secondly, the finding that different lighting conditions had no difference in accuracy, suggests that the lighting condition in which a face is captured, has little to no effect on identification performance. As aforementioned, these results should be taken with caution and more research is needed to validate this claim further as previous research would have suggested different findings. The trend in the miss responses in figure 6 should be highlighted as it would suggest that with a larger sample there is a higher possibility of finding a significant difference in the streetlight condition, compared to daylight and artificial light. This would have further implications for research and practice as previous studies with larger samples, showed differences in illumination (Braje et al., 1998). Findings from research in face perception would also argue that more shadows would results in less accurate identification as it can alter the visual representation of a face through camera (Adini et al., 1997). This again would suggest that streetlight condition in this task might have resulted in poorer accuracy, however this was not supported. These previous findings lead the researcher to question whether the current research findings are reliable based on inadequate sampling and flaws in the methodology. More extensive research would be recommended to further conclude the impact that these lighting conditions have on face recognition.

CCTV footage may be greatly effective to help in identification among the public or police if used appropriately in police investigations. Even when these images are of a low quality, they can be useful when released to the media or broadcasted to provoke identification by familiar people. Currently, CCTV images are used as evidence or in court, where people who are not familiar with them are asked to decide if the footage depicts the defendant. The findings from this study and from previous research (Bruce et al., 2001) would argue that this procedure should be avoided as similarities between images of the same or different people can often be misleading and unfamiliar face perception judgements are error prone. It has previously been highlighted that false identifications result in false convictions, which may have some major consequences for the legal, and criminal justice services (Clark, Benjamin, Wixted, Mickes, & Gronlund, 2015). False non-identifications, in turn, result in criminals given the chance to commit more crimes, ultimately making our society less safe.

Future research and conclusions

To conclude, the current research aimed to explore the differences between familiarity and lighting in accuracy of identifying a face to CCVT footage. The statistical analysis provided support in that a significant difference between familiar and unfamiliar faces was found across conditions. It can therefore be concluded that a familiarity advantage in consistent across viewing conditions, suggesting that familiar faces provide the most accurate identification responses. This can effectively be explained by sensitivity as a significant difference was again found for familiarity, suggesting that participants have enhanced sensitivity for familiar faces, which makes them easier to discriminate between the distractor faces. As no significant differences were found between the lighting conditions, it may be suggested that variation in realistic lighting conditions have little to no effect on identification performance. However, due to limited sample and methodological problems, it is not possible to fully determine the influence of lighting on face recognition accuracy. No clear bias was found between conditions, which suggest that the familiarity and lighting have no impact of the likeliness of choice in this sample.

There are some considerations to be taken from the research that could be valuable for future research. However, research has suggested there is no difference between matching and memory tasks on performance (Megreya & Burton, 2008), the lighting conditions used in this research should be explored further in other types of identification tasks to validate the findings further. This may provide results that are more generalisable to a range of different applied settings. It should also be considered that choosing from a line-up, not only relies on memory to retrieve a face, but also relies on social and metacognitive factors that are independent from recognition memory. This suggests that other psychological processes, such as, decision making, problem solving strategies and learning, which are experienced differently by each individual, may influence face recognition accuracy separately from contextual factors such as lighting, and familiarity investigated in this study. These should be explored more thoroughly in both witness identification and decision-making literature to gain a better understanding of all the variables that may influence false identifications.

Lastly, future research should also consider the limitations of the current research design and aim for a more controlled experiment and environment for the participants to take part in. This may result in larger differences in recognition accuracy between the lighting conditions, which may have more substantial implications for future research and practice.

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