The impact of personal perception on the identification of tattoo pattern in human identification

Abstract

Tattoos and body modifications have a significant role to play in the identification of individuals in a variety of forensic contexts. Despite this, little work has explicitly examined this topic. The aim of this study was to examine whether personal perception has an influence on the identification of tattoo images. A questionnaire was constructed containing a variety of tattoo images and distributed randomly, resulting in two hundred and eleven participant responses. The results indicated that the perception of tattoos has a high margin for error and interpretation. The conclusion of the study argues that a perception issue exists amongst individuals, however further work needs to be carried out to establish the degree of variation.

Introduction

Body modification is defined by Sheumaker and Wajda (2008, p68) as, "*the deliberate, permanent alteration of the human body for decorative, ritualistic, religious, or for cultural reasons*". Intentional modification of the body has been argued as being a defining feature of humans, and as such has long been acknowledged to be of great potential in the identification context. Recently one particular form, tattooing, has been receiving increased attention from the forensic sciences. Guharaj (2003, p55) explains "*scars have long been accepted as a form of identification*" and "*tattooing as it produces distinctive marks on the body of the individual, can be means of identification*". Scars, marks or tattoos on the deceased can be used as a starting point for comparison, providing possible identities which could be confirmed by using a primary identification technique, such as DNA analysis or odontology (Leclair, 2004). Clearly there are many types of body modification which can be useful for human identification beyond scars, unique marks and tattoos, including branding, binding, cutting, inserting implants under the skin, and piercing in order to change the body (Black and Thompson, 2007; Featherstone. M, 2003). Tattoos are particularly interesting due to their increase in popularity, the potential unique and personal designs and the variety of anatomical locations for them. Thus, they allow the opportunity for use as a method of human identification.

Tattoos and Human Identification

As Lee *et al* (2008) discuss, tattoos can be a beneficial tool for identification as when applied the tattoo pigments penetrate the skin deep into the dermal layer. As such, the pigments remain in place even when damage and trauma occur to more superficial aspects of the body. For example, it is acknowledged that tattoos can survive the severe heat of a mass fatality incident even when other possible methods of identification, such as, fingerprints and personal effects may have been lost due to the fire (Vij. K, 2008).

To illustrate the point, a valuable early example of tattoos aiding the identification process dates back to April 1935, in Coogee, Sydney. A man was reported missing from the beach and later that month a shark purchased by a local aquarium vomited a large amount of material, amongst which, was a human arm which contained a tattoo on the forearm. The victim's wife confirmed that the tattoo was identical to her husband's and his identity was subsequently confirmed (Vij ,2011).

One key problem with the use of tattoos in a forensic identification context, is that in order to match tattoos to ante-mortem information, their classification must be standardised. This can be problematic when the very potential of tattoos derives from their sheer uniqueness. In the past, there have been attempts to categorise and store tattoo designs with the aim of assisting the Disaster Victim Identification (DVI) process. Lee *et al* (2008, p2) explain that previously "*law enforcement agencies routinely photographed and catalogued tattoo patterns for the purpose of identifying victims and convicts*". We most often think of using tattoos for identification of victims and rarely consider its use for convicts, however this idea can be beneficial as it is often the case that alternative identifies can be assumed (Acton and Rossi, 2008). The drawback to this early catalogue was the ability to search the database easily to find a specific tattoo or mark, it was time consuming, expensive and laborious (Liu. J. 2007). Jain *et al* (2009) explain how subsequently a more complex system was created to aid the search for a specific mark or tattoo. As a result, a classification system was put in place known as ANSI/NIST ITL 1-2000 to categorise the different designs and patterns. This comprised of eight different categories, including human, animal, plant, flags, objects, abstractions, symbols and other images which were then further divided into over 80 sub-classes, as shown in Figure 1.

Figure 1: ANSI/NIST ITL 1-2000 Tattoo Classification (adapted from Lee *et al*, 2008)

Class Description	Class Code	Subclass	Subclass Code
Human Forms & features	**HUMAN**		
Animals & Animal Features	**ANIMAL**	Cats & Cat Heads	**CAT**
		Dogs & Dog Heads	**DOG**
		Other domestic animals	**DOMESTIC**
			VICIOUS
			HORSE
			WILD
			DRAGON
			BIRD
			INSECT
			ABSTRACT
			PARTS
			MANIMAL (Miscellaneous animal forms
Plants	**PLANT**		
Flags	**FLAG**		
Objects	**OBJECT**		
Abstractions	**ABSTRACT**		
Insignias & symbols	**SYMBOL**		
Other Images	**OTHER**		

To allow the images to be retrieved from the database, the images of the Scars, Marks, and Tattoos (SMTs) needed to be accompanied by textual annotation, therefore keywords could be searched. Interpol (2005, p28) stated that only "*64 alpha-numeric characters of free text describing marks, scars and tattoos*" are used. This limits the amount of detail that can be included with the image. This approach was not ideal and created problems since people inevitably perceived the tattoo images differently, which was also reflected in the accompanying text – all of which led to confusion over the different keywords used to describe the images. This led Lee *et al* (2008, p2) to state that "*this tattoo matching process based on human-assigned class labels is subjective, has limited performance, and is very time consuming*".

Perception is potentially such a huge issue within the field, especially concerning tattoo designs. More designs are available than there were when this system was devised, and they have become more complicated, nuanced and often are meant to have more than one meaning. Therefore, describing modern tattoos can be challenging. For example, a sleeve tattoo covers a high percentage of the arm and can be difficult to describe as they are large and include a great deal of detail with various interlinking images.

Lessig *et al* (2006, p135) describes a case study a tattoo aiding a positive identification during the 2004 tsunami DVI process. The male victim concerned (James Smith) was found to have a shark tattoo. Ante mortem data contained similar information. This provided a base for comparison to allow odontology to confirm a positive match.

Issues with perception

Throughout the recovery of the deceased and the subsequent mortuary processes during a mass fatality situation, the analysis and recording of all information and evidence may be subject to personal perception. At the start of the DVI process when recovering the deceased from the scene is the first instance in which perception becomes apparent. In the UK, Victim recovery teams complete the Association of Chief Police Officers (ACPO) victim label booklet, at this point all information recorded is based on their personal perception (Black, 2011). If this officer is recording personal effects for example, the decision to document the deceased wearing jacket, instead of a coat or jumper, is the perception of that individual officer. This has the potential to then continue to the mortuary, where mortuary officers receiving the deceased could possibly be influenced by the documentation from the officer at the scene. For example, the mortuary officers may have identified the deceased to be wearing a jumper, but having read the scene notes, now documents the deceased to be wearing a jacket. The additional pressure from time constraints within the mortuary, may also mean decisions are made more hastily about the item type, condition and the specific description given.

During a post mortem all information regarding the deceased is recorded using the DVI Interpol forms, these *"post mortem forms are printed on pink paper and the ante mortem forms are printed on yellow paper to avoid misinterpretation*" (Sweet, 2010). These forms are identical allowing the same questions to be asked to the relatives, concerning their loved ones, and also the post mortem examiner of the deceased. Therefore, both completed forms should, in theory, be quicker and easier to compare to find a match. However, problems could arise when filling in the forms as everyone's perception of an item is different. For this reason, secondary identification techniques, such as, personal effects cannot be used to solely identify the deceased (London Resilience, 2015, p27).

Outside of the DVI process we have another example where this can be an issue - witness testimony. Brimacombe et al (1997) conducted a study which compared the accuracy and perception of testimony by witnesses young and old, as well as the perception of reliability by jurors of different ages. The study found "*The seniors who took part in this research were generally less accurate than younger adults in recalling details of the staged crime*" (Brimacombe, 1997). This could also be true when recalling personal effects, scars, marks and tattoos belonging to a family member, causing inaccuracies in comparisons.

Content Based Image Retrieval (CBIR)

This early work ultimately led to the development of a Content-Based Image Retrieval (CBIR) approach. This system has been considered "*one of the major approaches to image retrieval that has drawn significant attention in the past decade*" (Yang,2004). Rather than searching image databases using metadata and keywords, it searches the images themselves using such things as colour and texture.
Thus the basic concept of this new system is to allow the computer to extract the visual content of the image, and remove the subjective human input. Yang (2004, p254) states, that "*relevant images are retrieved based on the similarity of their image features*". This means that the aspect of controversy concerning personal perception is ruled out, as the system will retrieve the images based on data and similarity, rather than keywords assigned to the image.

A technique which has been introduced into the CBIR system is known as Scale Invariant Feature Transform (SIFT) has considerably enhanced the matching performance (Jain, 2009). Lee *et al* (2008, p4) states that "*SIFT extracts reputable characteristic feature points from an image and generates descriptors representing the texture around the feature points*".

During a study by Lee et al (2008) to put this CBIR system to the test, two different image databases were used. The first used 4323 images which were downloaded from the internet. Lee *et al* (2008, p5) explains that "*these 90x90 colour images belong to eight main classes and thirty subclasses as defined in the ANSI/NIST ITL 1-2000*". In reality, images of SMTs will often be captured in non-ideal situations with image distortion or blurring. To ensure this was taken into account during the study, each image was transformed 20 times using blurring, changing the illumination, colour, aspect ratio and rotating the image. This created a sample database of 86,460 images from the original 4323 images. When the system was tested using this database the retrieval accuracy was 98.6% and the average execution time for feature extraction was 0.0005sec/image with the average matching time between an image pair being 0.005sec.

Further work has been undertaken using the tattoo database held by the Michigan State Police, which included 69,507 images that had been collected over a ten-year period. These images were reviewed and placed in three classes: good, bad and ugly. Lee (2008) explains "*the bad or ugly quality of tattoo images is mostly due to the small size of tattoo or because the tattoo has faded over time*". When the system was tested using this database, the retrieval accuracy was 77.2%, the average execution time for feature extraction was 0.0023sec/image with the average matching time between an image pair being 0.3255sec. This retrieval time is slightly longer than the internet database, as the images tend to be larger and take the computer longer to process. To increase the speed and accuracy of matching, recommendations to delete multiple images have been suggested. A limit to the size of the image file may also be useful. Both databases provided a good sample size and to simulate reality it was valuable to use a number of transformed images. This technique has proved to be a quick and successful technique, which is practical and also cost effective.

A CBIR system therefore has the potential to work well for identification using tattoos, however if this system was to be implemented during a mass fatality incident there are some additional considerations. For example, how will this system work when photographs are taken in poor conditions, various angles or if the tattoo has been damaged? There are many reasons why tattoos could be damaged during a mass fatality incident, for example, decomposition of the body, fire or skin damage (McClanahan, 2003). Any damage to the tattoo has the possibility to alter the percentage match produced by the CBIR system. The image CBIR uses is a photograph of a tattoo and the computer recognises that image, in essence, an analogue picture stored in digital form (Horace, 2007).

Aim

With all of the above in mind, the aim of this research is to understand whether perception has an influence on the classification of tattoo images with regard to subsequent forensic use. To achieve this, a questionnaire will be used to explore the interpretation of a number of images by both male and female across different age ranges.

In addition, a second aim was to explore if there was an alternative way to record tattoos which would improve on our current photographic approach.

Method and Materials

A questionnaire was designed which displayed a series of copyright-free tattoo images with corresponding space for written replies. The survey was easy to understand and simple and quick for the participants to complete thus reducing the potential for error (as noted by Oppenheim, 2005; De Vaus, 2002; Webb, 2002; Iarossi, 2006; etc). Demographic information about the participants was also collected.

Twelve different images were selected for the questionnaire as well as an additional image which was to be used as an example. When choosing the images for the questionnaire, consideration was given to type and style of tattoo. Some images were shown as images of tattoos on the body, others were basic images designs. This was done to provide a variation in the images shown to the participants and to see if this had any impact on their recognition of the image.

The decision to allow participants to write using free text for their answers was chosen, as originally a number of options were to be given to allow data to be analysed more easily. This type of question is known as an 'open question'. Brace (2008, p46) explains "*an open question is one where the range of possible answers is not suggested in the question and which respondents are expected to answer in their own words*".

A pilot study was conducted using 6 participants in order to allow constructive feedback to be given. The study was carried out to run through the questionnaire and recognise any possible difficulties that might affect the results (Blessing & Chakrabarti, 2009). All six participants were informally interviewed, and information was gained on both good and bad aspects of the questionnaire. Points such as, length of time to complete, clarity, understanding as well as, level of difficulty were all discussed (Brace, 2008). The final questionnaire was distributed randomly to two hundred and eleven participants with no specific demographics being targeted. This was to ensure real life was simulated and the results were not manipulated by selecting certain amounts of males and females within an age group.

The questionnaire was distributed digitally. Once all of the questionnaires had been collected, it was necessary to group the data received as it was in free text. If participants gave more than one answer per question, their first response was taken, and the others were discarded. For questions such as question thirteen, the turtle, many participants gave mixed answers. For example, Celtic symbol, Celtic shield, Celtic emblem and answers such as this, Celtic was taken as this was the key word within the answer.

Recent work (Shamata and Thompson, 2018) has shown that the use of 3D surface scanning can support the work of forensic medical practitioners, partly by allowing for surface detail to be recorded with topographic anatomical detail. This approach was attempted here using a FARO Gage Plus. The unit is defined as "*FARO's highest accuracy Gage Arm created for the machine shop, it includes a 4ft (1.2m) Gage Arm, base plate, probe kit, cables and a portable battery*" (FARO, 2009).

The experiment carried out included three separate tests. The first, creating a digitised version of the tattoo image on a flat plate. The second, creating a digitised image of a tattoo on a subject's arm and the third, a digitised copy of a tattoo that had been damaged. These three tests were chosen to see how time consuming, accurate and if it was possible to digitise firstly a stand-alone image and subsequently an image on the human body. The decision to digitise an image which had been damaged was to attempt to simulate a real disaster situation, where a tattoo on a body may have been damaged by decomposition, fire or missing parts of the body.

The probe used to record the points was fixed at 5mm, as this was the equipment available. However, "*the Gage operates through inter-changing probs at the end of the unit that take measurements points on command. These probes can be exchanged with other probes depending on the surface or material being measured*" (FARO, 2011). Had a smaller probe been available it may have been possible to record more points with more accuracy.

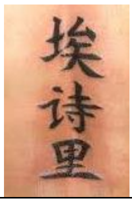
There were two possible ways of recording the outline of the tattoo. The first was to plot the shape of the design using the centre of the line on the image. The second method was to record both outer and inner lines of the image. As time was limited, the decision was made to record the image using the middle of the line. When plotting the points with the probe, it was vital the make sure the hand operating the FARO Gage was stable and steady. Human error or handshakes could create inaccuracies with results, having an unstable or unsteady hand could potentially mean incorrect points are plotted.

All images were digitised in approximately two to three minutes. As there were time constraints to complete this practical, due to the equipment availability, large amounts of time could not be spent recording points. In theory each image could have been recorded with as many points as time would allow, the more points recorded the clearer the image and the more accurate the results.

Results

Table 1 - Results from Questionnaire showing whether participants answered correctly or incorrectly

Question Number	Image the participants were asked to identify	Overall did participants get the right answer	Percentage of participants who answered correctly	Highest percentage gender who answered correctly	Highest percentage age group who answered correctly
1		NO	83.9%	Female	55-65

2		YES	77.30%	Female	18-25
3		YES	62.60%	Male	36-45
4		YES	55.90%	Female	18-25
5		NO	96.70%	Male	56-65
6		NO	63.00%	Female	56-65
7		YES	86.70%	Male	36-45

8		YES	65.90%	Male	66+
9		NO	74.90%	Female	18-25
10		NO	63.00%	Male	36-45
11		NO	50.20%	Male	26-35
12		YES	52.60%	Female	18-25

13		NO	95.30%	Male	18-25

The overall result of seven out of the thirteen questions being incorrect is not an accurate portrayal of how right or wrong participants were. There were certain questions which the participants answered with an exceptionally high percentage of incorrect answers and there were questions in which the percentage of correct responses was just enough to class the question as correct overall. This can be seen in question eleven where 49.8% were correct and 50.2% incorrect, as well as, question twelve, where 52.6% of participants answered correctly and 47.4% incorrectly. These percentages are so close that it may be hard to tell if the question was perceived correctly or incorrectly overall; had each individual's percentage error been calculated, this may be easier to establish.

Images for question four, eleven and twelve have very close out comes and it seems approximately half the participants were correct and half incorrect. There is no exact pattern, however the results received were similar answers to the correct answer. For example, question twelve, the correct answer was fire and some participants described the image as flames, fire ball and waves. All very similar to the correct answer and perhaps in a real-life scenario would be considered close enough to be correct.

There doesn't seem to be a generic pattern for the images that have a high percentage of correct answers or the ones that have a high percentage of incorrect answers. It might have been presumed that images with higher percentage correct answers would have had images that were more easily distinguishable and visa versa for the highest incorrect answers, however this was not the case. Individual perceptions of certain images varied. Some of the more abstract images seemed harder for individuals to distinguish, this can be clearly seen in questions five and thirteen.

Grouping the answers may have also affected the outcome and may have biased the result one way or the other. Overall, it seems that the men and the age group 56-65 answered with the most correct answers.

When relating the results from the questionnaire to the DVI process within a mass fatality situation, it can be seen from the variety of responses for each question that individuals had different perceptions of the same images. Not only that, but, the perception in some cases, was very different to the correct response. This could prove difficult during a mass fatality event, when collecting ante mortem data from the family or friends. Question Two shows a good example of this, where one participant has perceived the Chinese characters as trees. If the ante mortem data from a family stated the tattoo belonging to the missing person was Chinese characters, and the professional examining the deceased in the mortuary during a mass fatality event, perceived the tattoo as trees, this may result in the deceased remaining unidentified.

As stated earlier, James Smith may have remained unidentified but for the tattoo on his forearm, which was used as a starting point in his later identification (Vij,2011). A perception issue in previous cases, such as the shark/dolphin tattoo of the Lessig *et al* (2006, p135) case study, is confirmed by the results from this perception questionnaire.

4.1.2 Digital Inputting

Since the questionnaire results indicated that perception amongst individuals varies, it has confirmed the need for a more up to date method of searching and comparing images, without the influence of perception. With this in mind, using an engineering-based system for micro measuring, a company called FARO will be investigated to see if their 3D measuring devices could be used to digitise a tattoo image effectively for use within a mass fatality situation.

The initial introduction to the engineering-based FARO measuring system, was a brief five-minute demonstration of the basic measuring functions. After which, the instructor demonstrated planes and profile measurements. To be allowed access to the FARO measuring arm in a busy engineering environment was very valuable. Being given the time to explore the possibilities with this apparatus and observe a fully trained operative, who was familiar with the machinery, gave the opportunity to witness the ease of use after full training.

Overall, the testing produced an image similar to that of the original tattoo. It was obvious that the more time dedicated to recording as many points as possible, the more accuracy and the more clarity the digitised image achieved. However, the image produced during this experiment was a clear representation of the test tattoo. In terms of accuracy, the FARO apparatus proved to be very simple, effective and accurate. Again, the precision can be improved by using a smaller probe and spending more time working on the image (FARO, 2009).

Further testing using different scenarios would be needed to establish how effective this equipment would be for digitising damaged tattoos. Understanding how the equipment works in poor conditions, with decomposing remains and how accurately it records, requires further investigation.

Digitally mapping a tattoo gives the opportunity for recognition by computer analysis of a digitally input damaged image. The CBIR system recognises shapes and points on the images, but is unable to extrapolate from these images, a complete picture from a partial image (Horace, 2007). Using the CBIR system in conjunction with a digital mapping system, may be beneficial by eradicating human perception. A computer, using digitally input points has no personal perception issues and would search its database for matching points. The points, in this case, would be representative of a scar, mark or tattoo on a body. The computer would also be able to search for particular aspects of a tattoo. This would be useful when searching for a complete tattoo but having a damaged tattoo as the starting point.

To use this type of apparatus during a mass fatality event, could provide the ability to identify the deceased more quickly, as it would provide a starting point for comparison. The digitisation of the tattoo may allow the comparison process to be carried out faster, as it would be done by computer, instead of the slow laborious process of photographing and comparing the images by eye. However, this would only be the case when the deceased had a tattoo.

Discussion

The purpose of this study was to explore the possibility of interpretation being an issue when looking at tattoo images during the Disaster Victim Identification (DVI) process. A questionnaire was devised containing several images with the participants being instructed to write down what they saw, without conferring. The results produced from this questionnaire highlighted the need for a system to compare ante mortem and post mortem tattoo images without the issue of perception. A Content Based Image Retrieval (CBIR) system was researched as a potential solution to this problem, however several possible flaws could limit its success and a CBIR system may not be adequate for mass fatality situations on its own. Simply photographing the deceased's tattoo and running it through the CBIR system may cause problems with the percentage return in some cases. Image size and scale may be an issue. If the tattoo is distorted or damaged from cuts, decay or damage by fire, this may affect the percentage match when presented to the CBIR system, as the points that it compares will have been altered.

The results of the preliminary surface scanning experiment demonstrated that it is possible to record tattoos in detail and in three-dimensions. However, when considering this approach, the integration into the DVI process alongside a CBIR system must be considered. FARO (2011, p2) state "*the FARO Gage sets up in seconds and allows anyone to measure parts and assemblies easily, quickly, and accurately. Now with Bluetooth cable-free operation, you can inspect and digitize wirelessly up to 30ft. away*". This would allow the machinery to be set up quickly in any setting, at the scene or in the mortuary. The Bluetooth capability would mean information could be sent, making the transfer of data or the digitised image, a lot easier. The fact the FARO allows various diameters of probe to be interchanged is of great benefit, it would allow the probe to be changed according to the complexity, size and thickness of the tattoo design (FARO, 2009). FARO has also produced a digital measuring device with an integrated computer. This device is portable and therefore allows the ability to be transported for use within a temporary mortuary.

The technique of digitising tattoos could be very useful for the DVI process. If enough detail is captured when plotting the points, and enough time is spent profiling the image, any issues with poor mortuary conditions affecting the post mortem photographs of the tattoo would be eradicated. If a temporary mortuary has been set up, sometimes the conditions and resources may be limited (Rai, & Anand, 2007), if this is the case simply photographing the tattoo may limit the quality and clarity of the image. Lighting, angles, height and condition the deceased has been kept in, may all be limiting factors when producing the photograph of the tattoo. The ability to photograph curved surfaces without distortion is a problem for the CBIR system, for example a large tattoo following the curve on an individual's arm would produce a distorted image. If the photograph produced in these conditions is poor then this may affect the percentage match when using it with the CBIR system, as it picks out shapes within the tattoo (Prasad, 2004). As mentioned, within the original CBIR testing by Lee *et al* (2008), some of the percentages were affected by the quality of the image. All of these flaws could potentially be eliminated by the use of a digitised input. The FARO apparatus has the ability to record the tattoo on a three-dimensional plane.

An obvious drawback would be cost. The equipment itself along with the computer, associated software packages and training would cost a great deal to implement initially and keep up to date (Tassey, 2007).

The possibility of developing a CAD based program using a finer point probe to draw a continual line round the tattoo would allow a three-dimensional digitisation, which would give a precise size and scale to the tattoo. Also, this would provide an opportunity to colour or replicate the digitised image. The digitisation could also be pasted onto a photographed image of a body part to give a more realistic illustration of a tattoo.

If this method was to be used during a mass fatality incident, the tattoo may be damaged or suffering from decomposition (Di Maio & Dana, 2007). The image may be distorted or incomplete, possibly making the plotting of the points more difficult. Further work would need to be carried out in this area. In addition, it may prove beneficial to experiment with different types and varieties of tattoos with different degrees of damage.

Time would need to be taken to explore other types of digital measuring devices to see if there would be a more suitable one for this purpose. The FARO apparatus, although it worked well, was the only digital measuring apparatus readily available at the time and there may be more accurate, lighter and portable machinery that could be used.

Limitations & Future Work

For future studies, it may be beneficial to recruit more participants, and to make the age ranges more compressed, for example, eighteen to twenty, twenty-one to twenty-three, twenty-four to twenty-six and so on. This may allow for greater appreciation of the influence of age on the results. Trends, fads or fashion with regards to tattoos may be illustrated within this. Further, to get a better idea of whether having a tattoo or not affects how the participants perceive the image, a greater proportion of tattooed participants may be needed.

Although the results have highlighted the potential problems deriving from individual descriptions of tattoos, it is important to appreciate that when it comes to descriptions provided for the tattoos by family members or friends concerning a missing person, it may not necessarily be a case of correct or incorrect. Closeness of description may be just as significant. For example, if the family member described a tattoo as a lizard and the actual tattoo is of a gecko, this would potentially be close enough for professionals to use as a basis for matching and stimulation of further identification methods (London Resilience, 2015. Therefore, for future work, it may be beneficial to conduct a grading system to note how close participants were to the 'correct' answer. The use of a board of individuals may be beneficial in allowing the grading system to be carried out using a number of people's perceptions, possibly calculating the mean.

The initial grouping of the participants' responses could have been a disadvantage as some of the participants had given more than one answer. The answers had to be placed into the closest groups, slightly altering the actual responses given. Although it assisted in the analysis, the grouping may also have meant that some answers were accepted or rejected as correct responses, possibly altering the final percentage slightly.

Conclusion

Following the completion of this study, it is apparent that individuals perceive tattoos differently. There is a great opportunity to utilise body modification within the Disaster Victim Identification process. With regards to the questionnaire within this study, it is unclear the degree of variation between individuals' perceptions, without comparing an accurate percentage error for each participant. There doesn't appear to be a set pattern of the specific age or gender of individual who answered correctly or incorrectly for all images. In terms of human identification, this issue would mean that when comparing ante mortem descriptions of tattoos to the deceased, or post mortem images of the deceased's tattoos, mistakes could be made.

Lee *et al* (2008) developed a Content Based Image Retrieval (CBIR) system with the intention of eradicating such issues. However, it is clear that potential problems could affect the efficiency of this system. Further factors such as, decomposition, trauma to the body, scarring, amputation or fire damage may also limit the system from returning a high percentage match when comparing ante and post mortem images of the tattoos.

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