Forensic Science International 278 (2017) 411.e1–411.e8

Contents lists available at ScienceDirect

Forensic Science International

journal homepage: www.elsevier.com/locate/forsciint

Forensic Anthropology Population Data

On the integral use of foundational concepts in verifying validity during skull-photo superimposition

Paul T. Jayaprakash*

Forensic Science Program, Universiti Sains Malaysia, Kubang Kerian, 16150, Kelantan, Malaysia

ARTICLE INFO

Article history:
Received 11 May 2016
Received in revised form 23 March 2017
Accepted 24 April 2017
Available online 16 May 2017

Keywords:
Forensic anthropology
Skull-photo superimposition
Use of 'life-size' images
Quantitation in qualitative research
Dynamic skull orientation using tragus
Validity in superimposition method

ABSTRACT

Often cited reliability test on video superimposition method integrated scaling face-images in relation to skull-images, tragus-auditory meatus relationship in addition to exocanthion-Whitnall's tubercle relationship when orientating the skull-image and wipe mode imaging in addition to mix mode imaging when obtaining skull-face image overlay and evaluating the goodness of match. However, a report that found higher false positive matches in computer assisted superimposition method transited from the above foundational concepts and relied on images of unspecified sizes that are lesser than 'life-size', frontal plane landmarks in the skull- and face- images alone for orientating the skull-image and mix images alone for evaluating the goodness of match. Recently, arguing the use of 'life-size' images as '*archaic*', the authors who tested the reliability in the computer assisted superimposition method have denied any method transition. This article describes that the use of images of unspecified sizes at lesser than 'life-size' eliminates the only possibility to quantify parameters during superimposition which alone enables dynamic skull orientation when overlaying a skull-image with a face-image in an anatomically acceptable orientation. The dynamic skull orientation process mandatorily requires aligning the tragus in the 2D face-image with the auditory meatus in the 3D skull-image for anatomically orientating the skull-image in relation to the posture in the face-image, a step not mentioned by the authors describing the computer assisted superimposition method. Furthermore, mere reliance on mix type images during image overlay eliminates the possibility to assess the relationship between the leading edges of the skull- and face-image outlines as also specific area match among the corresponding craniofacial organs during superimposition. Indicating the possibility of increased false positive matches as a consequence of the above method transitions, the need for testing the reliability in the superimposition method adopting concepts that are considered safe is stressed.

1. Introduction

Transitions from the concepts recommended as foundational for video superimposition method have been noted in the methods described by authors using computer assisted superimposition processes (Table 3 in Jayaprakash [1]) including Gordon and Steyn [2] and the impact of such differences on the method reliability is a matter of current debate [3]. Gordon and Steyn [2] cite the traditional video superimposition method described by Austin-Smith and Maples [4] as the basis for their methodology. Austin-Smith and Maples [4] used face-images, although at lesser than 'life-size', but filled the monitor screen and then overlaid 3D skull-images from real skulls to fit the face-images guided by tissue thickness markers, included the tragus-auditory meatus relationship in addition to ectocanthion-Whitnall's tubercle relationship when orientating the skull-images in relation to the posture seen in the face-images and evaluated the match among the superimposing skull- and face-images relying on wipe images in addition to images seen in mix mode. However, Gordon and Steyn [2,3] superimposed scanned 3D skull-images and scanned cadaver face-images of unspecified sizes at lesser than 'life-size', relied merely on landmarks on the frontal plane for orientating the skull-image without including the tragus-auditory meatus relationship and assessed the goodness of match relying only on mix images [2] without including images in wipe mode. Opposed to lesser false positive matches (8.5%) in Austin-Smith and Maples, the two fold increase in false positive matches (17.3%) in the morphological method in Gordon and Steyn [2] supports the possibility that the increase in false positive matches in the latter is due to method transitions (Table 1). In a recent report, Gordon and

* Fax: +60 9 7677515.
E-mail address: ptjaya@usm.my (P.T. Jayaprakash).

http://dx.doi.org/10.1016/j.forsciint.2017.04.021
0379-0738/

Table 1
Abstract of samples and methods used for assessing reliability in skull-photo superimposition in the traditional video based (Austin-Smith and Maples [4]) and computer assisted (Gordon and Steyn [2]) superimposition methods.

Category and type	Traditional video vision mixer based method (Austin-Smith and Maples [4])	Computer/software based method (Gordon and Steyn [2])
Image scaling		
Skull-image size adjusted using tissue thickness markers that fell inside the face-image outline	Mentioned	Not mentioned
Face-image filling the monitor screen	Mentioned	Not mentioned
Size of monitor screen	Mentioned	Not mentioned
Skull orientation		
Relies merely on landmarks in frontal (eye)-plane	No	Yes
Relies on landmarks in frontal (eye) and rear (ear) planes	Yes	No
Verification of the skull orientation		
Integral during the process of overlay- constructive	Yes	No
Image mode used		
Mix images alone	No	Yes
Mix and wipe images	Yes	No
Sample appropriateness		
Face photograph sample	Mug shots of living individuals — appropriate at operational level	Cadaver face photographs — inappropriate at operational level
Skull sample	Video images of real (dry) skulls — appropriate at operational level	Incompletely scanned 3D images of skulls — inappropriate at operational level
Applicability		
Applicability of results in real life case situations	Applicable	Not applicable
False positive matches during reliability testing		
False positives (%) in frontal view skull- and face-image superimpositions	8.5%	17.3% (morphological method)

Steyn [3] chiefly defend the use of images at lesser than 'life-size' in their earlier experiment [2] and state that they '*did not depart from any standard but followed the foundations of the technique*' adding that '*no empirical research results exist to prove that traditional methods provide better results*.' This article describes the importance of using 'life-size' images and integrating tragus-auditory meatus relationship during the process of superimposition adding a note on the benefits of wipe facility when evaluating a match and sample appropriateness when testing method reliability.

2. 'Life-size' enlargements: critical requirement for scaling and quantitation

During the comparison of characteristics between a skull and a putative face photograph using superimposition method, the use of the skull-image in its '*natural*' size and the face-image in a size '*as near as might be feasible*' – often designated 'life-size' – has been considered a '*crucial*' and '*safer*' plan for a scientific experiment [5] and was followed by many authors describing traditional methods of superimposition [6–24]. Early authors reducing the images to half-size acknowledged constrain by the size of the ground glass [25,26] and Austin-Smith and Maples [4] indicated that they used a 14-in. monitor screen in a Panasonic model WV-5410. Although the size of such video monitor would be insufficient for projecting a face-image in 'life-size' these authors specified filling the face-image on the monitor screen and then overlaying the skull-image to fit the face-image outline guided by tissue thickness markers. Gordon and Steyn [2] advocate that retaining 'life-size' images is '*archaic*' and suggest that '*As long as the skull and the photograph are scaled/adjusted appropriately, it does not matter, for example, what the size of the computer monitor was*'. Neither the method description in Gordon and Steyn [2] nor their recent review [3] mention measuring distances between the landmarks in the real skull or its 3D image, an obligation for *scaling* the skull-image size and then for resizing the face-images. Preferring to use images of unspecified sizes that are not scaled in relation to the size of the real skull or its 3D image eliminates any possibility for quantitation such as when verifying scientific orientation of the skull-image, assessing symmetry congruencies along the skull- and face-image outlines or quantifying the proximity among related skull-face landmarks as detailed below.

i) Problems in relying on all the '*four*' orientation landmarks for sizing face-images

Austin-Smith and Maples [4] described two distinct steps in the following sequence: One enlarging a face-image guided by tissue thickness markers on the skull-image that fit the face-image outline and the other orientating the relatively enlarged skull-image by aligning the Whitnall's tubercle and auditory meatus with the exocanthion and tragus in that face-image. Traditionally, authors reporting superimposition method described obtaining relative or 'life-size face-image and orientating the skull-image as two distinct procedures in the same sequence [10,18–20,25,27,28]. However, Gordon and Steyn [2] state that '*A total of four orientation landmarks were used, and comprised of nasion, subnasal point and ectocanthion (a paired landmark)*' and that the '*The orientation landmarks ensured that the skull was correctly aligned and sized with the photo so that the process of determining a match could follow.*' When the extent forward or backward tilt in a 2D face-image remains unknown, linear measurements along the vertical plane obtained from a skull in 3D form cannot be relied on for sizing face-images simply because vertical measurements in face-images are influenced by the extent of tilt of the face [29]. On the other hand, linear measurements between two landmarks on the horizontal plane such as bizygomatic width [25] or inter Whitnall's tubercular distance [20] obtained from a real skull are shown useful for sizing a face-image since such horizontal measurements are not influenced by the extent of tilt in face-images. Here, it is difficult to conceive how Gordon and Steyn [2] concomitantly used all the