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Case Report

# A geometric morphometric evaluation of the Belanglo 'Angel' facial approximation

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ABSTRACT

In August 2011, a 2D facial approximation was undertaken of remains discovered in Australia's Belanglo State Forrest; in October 2015, the young woman was identified. Referencing three photographs of the young woman as she appeared in life and a database of 64 sex, age, head pose and population matched images, the facial approximation is evaluated for relative shape accuracy through the application of geometric morphometrics. The results are that the facial approximation is significantly similar to the images of the young woman in facial morphology ($p = 0.002$) when most of the variance due to depicted head pose is removed from the analyses. The geometric morphometric analyses, however, also highlight the facial approximation's face and feature discrepancies, some of which would have likely disrupted familiar face recognition. Although predominantly verified methods were applied in 2011, they are limited in their predictive accuracy, not every feature of the face has a verified method to apply, and practitioner errors as well as photographic distortions are apparent. Furthermore, an assumption that the verified methods require inter-feature agreement (in this instance eye spacing and mouth width) was proved to be false. Overall this study shows that it is possible to assess the morphological accuracy of a forensic facial approximation when a number of antemortem images are available, though the influence of photographic distortion within 2D photographs will always preclude a precise metric assessment.


## 1. Introduction

In August 2010, the skeletal remains of a young woman (15–25 years, European population affinity) were found in Australia's Belanglo State Forest. A year later, the New South Wales Police requested a facial approximation and the results were released to the national media in December 2011 (Fig. 1a). Although the estimation of this young woman's facial appearance assisted in generating a substantial number of new leads, none resulted in a positive identification. In 2013, the methods used to estimate facial appearance formed part of a critical comparative review of the largely invalidated and popular forensic facial reconstruction approach [1]. In October 2015, the young woman, referred to in the Australian media as "Angel", was identified as Ms Karlie Jade Pearce-Stevenson, facilitated by a lead unconnected to those generated by the facial approximation. The facial approximation essentially failed in its primary purpose, which is assist in identification. However, an evaluation of the predictive accuracy of a facial approximation is part of the process when the face is estimated as applied research, and ideally all forensic estimations are evaluated, regardless of the outcome.

Some of the local media coverage included comments regarding the similarity between the facial approximation and the photographs of Ms Pearce-Stevenson which predominated in the media following her identification: e.g., "remarkably accurate" [2]; "amazing likeness" [3]. Such a post hoc response to a facial approximation is fairly commonplace [4,5] and does not reflect the actual recognisability or accuracy of the results. A facial approximation is undertaken to stimulate leads to identification from colleagues, friends and family members [6,7], but face recognition studies show that individuals who are unfamiliar with the person depicted utilize different neural mechanisms, attend to different aspects of the head and face [8], and essentially engage in face-matching [for reviews,see 9–11]. Face-matching is frequently confounded by variation in head pose even when the images are captured under the same photographic conditions, and the most salient feature is the shape and hue of terminal head hair [8,12–14]. In contrast, familiar face recognition is influenced by facial configuration rather than individual features, though this is a more complex neural process than past studies have indicated [15],

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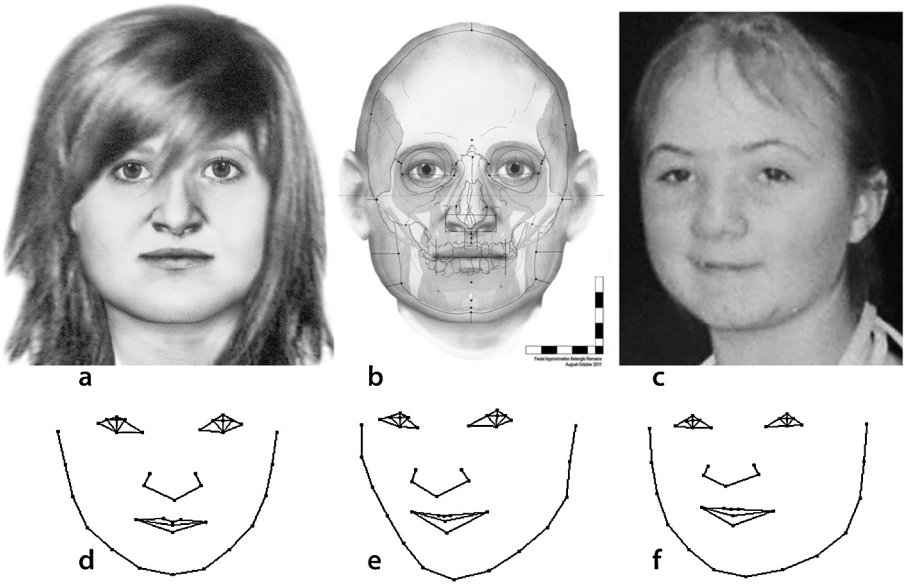


**Fig. 1.** The facial approximation of the Belanglo 'Angel' and Ms Pearce-Stevenson.
The facial approximation (a, b), one of the photographs of Ms Pearce-Stevenson that has appeared in the Australian media (c), wireframes representing the three photographs used in this evaluation: frontal/downwardly posed (d), right turned/downwardly posed (e), right turned/upwardly posed (f). The photograph of Ms Pearce-Stevenson is reproduced with permission (refer main text).

is head-pose invariant, though this is shared to some extent with unfamiliar face recognition [16], very rapidly processed [17], and occurs even when highly degraded CCTV images are used [18].

Familiar assessment has been undertaken with a facial reconstruction created using CT scans of a colleague's skull and teeth [19], and there is a report of parents being unable to recognize the facial reconstruction of their child, even after being told this is who the results were intended to predict [20]. It is, however, generally agreed that a facial approximation undertaken with a forensic case cannot be easily, or ethically, tested for familiar face recognition [21]. As a consequence the recommended accuracy test of a facial approximation is visual assessment by unfamiliar participants [e.g.,21–23], which has been found to require a minimum of 115 assessors [21]. Metric assessments of accuracy occur within laboratory-based studies, but no actual forensic estimation has been formally evaluated for predictive accuracy since at least 2001. However, this is likely due to traditional anthropometric measures requiring standardized photographs of the identified individual to undertake a comparison.

Traditional anthropometrics is reliant on direct measurements taken from a person's head and face (i.e., using callipers) or scaled, orthogonal images (e.g. 3D scans). If anthropometric measures reference photographs, each individual needs to be photographed bearing the same head orientation and facial expression, and the camera angle and lens-subject distance needs to be standardized so as to reduce, but not entirely remove, the effect of perspective distortion [see,for example,24]. Images taken outside of the laboratory, including arrest photographs, tend not comply with these requirements [25]. Instead, most photographs typically differ in head pose, facial expression, camera make and camera angle as well as variation in lens-subject distance, and this holds true for the photographs of Ms Pearce-Stevenson published in the Australian media.

Geometric morphometrics is a tool for statistical shape analysis that compares the patterns of shape variance across a suite of homologous landmarks, and therefore accounts for the interaction of all landmarks simultaneously rather than piecemeal. Because of its capacity to process complex patterns of shape variance, previous research has found that geometric morphometrics can enable statistically meaningful comparisons between (i) highly disparate image types depicting the face of the same individual [25,26], (ii) widely divergent palaeoart facial reconstructions of the same skull [27], and (iii) between images of different individuals displaying a range of habitual head pose variations [28]. It is because of this ability to identify shape variance due to head pose that geometric morphometrics has been applied for this evaluation of the facial approximation of Ms Pearce-Stevenson, though photographic distortion remains a confounding variable.

## 2. Materials

### *2.1. Photographs of Ms Pearce-Stevenson and the facial approximation*

Four photographs of Ms Pearce-Stevenson have appeared in the Australian media since her identification was announced [e.g.,29–31] and the three that most clearly display her face and features were used to estimate the morphological accuracy of the facial approximation. Permission was granted to reproduce Fig. 1c (Ava Benny-Morrison [30]), and this image, together with the two remaining photographs are represented in Fig. 1d–f by the landmark coordinate wireframes used in the geometric morphometric analyses.

The three photographs are unscaled and informally posed. Two depict Ms Pearce-Stevenson seated and gazing upwards (Fig. 1d, e). While neither seems to display an upwards head orientation, both appear to have been taken from an angle above head height, which, on the basis of past forensic photographic comparisons using geometric morphometrics [e.g.,32–35], results in a facial morphology that shares some of the shape changes resulting from a downwardly pitched head pose (the upper face is expanded and lengthened while the lower face is contracted and foreshortened [26]). One photograph is of comparatively low resolution and depicts Ms Pearce-Stevenson fairly frontally orientated with a relatively neutral/serious facial expression (Fig. 1d), while in the higher resolution photograph her head is turned to the right shoulder (both eyes are visible but the right ear is obscured) and Ms Pearce-Stevenson is displaying a closed-mouth smile (Fig. 1e).