



Forensic age progression for missing person investigations: A pilot evaluation of recognition accuracy

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ABSTRACT

Forensic age progression is widely used to support long-term missing person investigations by estimating an individual's potential current appearance. Empirical validation of this technique remains limited, and systematic evaluations of its accuracy are scarce. This pilot study examines the recognizability of age-progressed facial images derived from childhood and adolescent photographs of two adult participants (Subject A and Subject B) attending a scientific congress, aiming to provide preliminary insight into the conditions under which age progression may succeed or fail.

A forensic anthropologist—blinded to the participants' current appearance—produced age progressions to age 25 following established morphological assessment principles. The resulting images were anonymously displayed during the meeting, where 105 attendees with no specific training in age progression attempted to identify the portrayed individuals among those present.

Recognition performance differed between the two subjects, with 79.1% correct identifications for Subject A and 54.3% for Subject B. Qualitative comparison between the age-progressed and current photographs showed both accurate feature predictions and discrepancies influenced by lighting conditions, facial orientation, and individual morphological variation.

This preliminary investigation highlights the potential value of forensic age progression while emphasizing its challenges. The findings underscore the need for larger, systematically controlled validation studies to improve the reliability and forensic applicability of age progression in missing person cases.

1. Introduction

The increase in the number of missing persons worldwide has highlighted a growing international concern. Monitoring activities conducted by global organizations have made it possible to clearly determine the extent of the problem: hundreds of thousands of individuals, especially children, disappear every year across different regions of the world [1–4]. Given the seriousness of the issue, forensic

sciences have long focused on developing tools that can support both the immediate search for missing persons and long-term investigative efforts [2].

Among these tools, forensic age progression is widely used by international agencies to update the facial appearance of individuals who have been missing for years, relying on scientific knowledge of facial growth and aging [5–40]. Age progression builds upon well-established anthropological evidence showing that facial morphology follows

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specific developmental trajectories across childhood, adolescence, and adulthood. As summarized in the authors' previous review [16], soft tissues adapt to craniofacial skeletal growth, dental maturation, and proportional changes in the neuro-cranial and splanchno-cranial regions. Once skeletal maturity is reached, facial aging continues due to endogenous factors—such as sex, ancestry, and genetic predisposition—and exogenous factors, including lifestyle, nutrition, environmental exposure, and substance use [16]. These elements contribute to the gradual modification of soft tissue volume, ligament laxity, gravitational effects, and wrinkle formation, which together shape the adult aging process.

Despite its widespread operational use by organizations such as the National Center for Missing & Exploited Children and similar institutions worldwide, empirical validation of forensic age progression remains limited. Few studies have systematically evaluated its accuracy, and those available often rely on restricted samples or retrospective case analyses [12–15,17,18]. Moreover, the assessment of age progression outcomes is complicated by the fact that recognition of unfamiliar faces—rather than familiar ones—is notoriously unreliable. A robust body of psychological literature demonstrates that unfamiliar face recognition is highly error-prone and sensitive to variations in lighting, pose, image quality, and external cues [24]. These findings are particularly relevant for age progression, as the individuals tasked with evaluating an age-progressed image (law enforcement officers, the general public, or investigators) typically do not personally know the missing person. Studies such as Lampinen *et al.* (2012) have emphasized how age-progressed images may be especially difficult to match accurately under unfamiliar-face conditions [25].

In this context, small-scale pilot evaluations provide meaningful preliminary insight into the strengths and limitations of age progression. The present study aimed to explore the recognizability of age-progressed images produced from childhood (age 5) and adolescent (age 15) photographs of two individuals. The age progressions were generated by a forensic anthropologist blinded to the subjects' current appearance and subsequently tested in an ecological setting during a scientific congress. The present work is explicitly conceived as an exploratory pilot study aimed at applied validation of forensic age progression under realistic unfamiliar-face recognition conditions, rather than as a test of technical innovation. Although modest in scale, this design allows for the examination of both morphological consistency and perceptual recognition performance in a realistic unfamiliar-face scenario.

2. Materials and methods

2.1. Subjects and photographic material

The subjects of this study were two English women affiliated with Goldsmiths, University of London, referred to as Subject A and Subject B.

Both provided informed consent for participation, image use, and publication. For each subject, two photographs were collected: one taken at age 5 and one at age 15 (Fig. 1). The current appearance at age 25 was not disclosed to the forensic anthropologist responsible for the age progression.

The childhood and adolescent photographs were evaluated for resolution, lighting, contrast, and visibility of key facial features, following common criteria described in previous studies on facial approximation and age progression [12,14,15,26–31]. Although minor lighting imbalances were present, all images were deemed adequate for morphological analysis.

2.2. Morphological assessment protocol

A morphological analysis of each subject's facial features was conducted according to established anthropometric and forensic criteria described in the scientific literature on craniofacial growth and facial aging [16,41]. The assessment included: face shape; eyebrow morphology; eyelid fold type; nasal bridge and nasal tip morphology; upper and lower lip contour. For each feature, developmental changes between the age-5 and age-15 photographs were compared to identify age-related modifications. This approach aligns with previously published age-progression methodologies [12–18,26,27,32,33].

2.3. Selection of reference images

High-resolution copyright-free photographs were collected from online databases to serve as reference images for compositing facial features. Only facial components with morphologies consistent with the subjects' analyzed traits were selected. Each reference feature was isolated using digital layer-based extraction. This method parallels standardized digital age-progression workflows described in previous studies [26,32].

2.4. Digital compositing and colour correction

Age progression was carried out using Adobe® Photoshop following a multi-step digital compositing workflow: feature extraction (facial components were cut from reference images and placed as separate layers; tonal and color adjustments (tonal values were adjusted using Photoshop's Color Balance tool); edge blending (layer edges were blended using a soft eraser to achieve realistic transitions consistent with digital imaging recommendations [26,27]); and global refinement (skin texture, lighting, eye color, and hair color were harmonized with the original photographs, consistent with typical age progression protocols). The final composites represented the estimated facial appearance at age 25.



Fig. 1. Photographs of subject A at ages 5 (a) and 15 (b), and subject B at ages 5 (c) and 15 (d).

2.5. Age-progression evaluation procedure

The two age-progressed images were printed as mugshot-style photographs and anonymously distributed during a scientific congress organized by Goldsmiths, University of London. A total of 105 attendees participated voluntarily. Participants had no specific training in age progression or facial comparison.

Each participant was asked to identify the person portrayed in each age-progressed photograph among the individuals present at the congress. Responses were categorized as: correct answer (accurate recognition); incorrect answer (incorrect identification); no answer (inability or refusal to respond).

2.6. Statistical analysis

Descriptive statistics were computed for all response categories (correct, incorrect, no answer). For inferential purposes, recognition accuracy was evaluated by comparing the proportion of *correct* versus *incorrect-given* responses between the two subjects. Differences were tested using Pearson's Chi-squared test, with significance set at $p \leq 0.05$, following standard procedures for categorical data [42]. Given the pilot nature of the study and the extremely small sample size, inferential statistics are reported solely for exploratory purposes and should be interpreted with caution.

3. Results

3.1. Photographic analysis

All photographs used for age progression presented sufficient resolution and clarity to allow detailed morphological assessment.

For Subject A, the age-5 photograph (Fig. 1a) exhibited mild shadowing on the right side and strong illumination on the nasal region; however, all facial features remained clearly discernible. The age-15 photograph (Fig. 1b) showed slightly uneven lighting but adequate visibility of morphological traits. In both images, the head was oriented slightly to the left, and the subject displayed a mild smile.

For Subject B, the age-5 photograph (Fig. 1c) showed more pronounced light imbalance, with a wider shadowed area, but still allowed adequate visualization of the facial features. The age-15 photograph (Fig. 1d) presented homogeneous lighting and a neutral expression. In both images, the head was slightly rotated to the right.

3.2. Morphological analysis

The morphological assessment revealed consistent developmental traits for both subjects across the childhood and adolescent photographs.

For Subject A, the face displayed an oval shape (Fig. 1a and b), with eyebrows characterized by a triangular morphology (Fig. 2a and b). The eyelids showed a central fold (Fig. 2a and b), while the nose presented a narrow and elongated bridge with a slightly rounded tip (Fig. 3a and b). The lips exhibited a well-defined Cupid's bow in the upper lip and a rounded contour in the lower lip (Fig. 4a and b).

For Subject B, the face showed a rounded shape (Fig. 1c and d), and the eyebrows exhibited a wavy configuration (Fig. 2c and d). The eyelids presented a medial fold (Fig. 2c and d). Nasal morphology was

characterized by a short and wide nasal bridge with a rounded tip (Fig. 3c and d). The upper lip appeared V-shaped, while the lower lip maintained a rounded outline (Fig. 4c and d).

3.3. Age progressed images, and comparison with current appearance

Digital compositing produced age-progressed images for both subjects (Fig. 7a–d).

The final images incorporated colour correction values applied to each facial feature, as reported in Figs. 5 and 6.

For both subjects, several morphological traits were successfully approximated. Subject A: The age-progressed image preserved the overall face shape, eyebrow morphology, eyelid configuration, and nasal bridge characteristics. Minor discrepancies included a more rounded nasal tip and a fuller upper lip in the age-progressed image. Subject B: The age-progressed image captured face shape, eyebrow type, and general nasal structure. Differences included a slightly more arched left eyebrow and reduced prominence of the medial eyelid fold relative to the current appearance.

3.4. Recognition task results

A total of 105 participants completed the recognition task for each subject. For Subject A, 83 participants (79.1%) correctly identified the individual depicted in the age-progressed image, while 4 participants (3.8%) provided an incorrect identification. Additionally, 18 participants (17.1%) did not provide any response. For Subject B, 57 participants (54.3%) correctly recognized the individual, whereas 26 participants (24.8%) gave an incorrect answer. A total of 22 participants (20.9%) did not respond to the identification request. These data are reported in Table 1. "No answer" responses were reported descriptively but excluded from inferential analysis, as they do not reflect measurable recognition performance.

3.5. Inferential analysis

Recognition accuracy differed significantly between the two subjects.

Pearson's Chi-squared test comparing correct vs incorrect-given responses yielded: $\chi^2 = 14.0$, $p = 0.00025$, indicating significantly higher recognizability for Subject A relative to Subject B.

4. Discussion

The results of this pilot study offer preliminary insight into the recognizability of age-progressed facial images generated from childhood and adolescent photographs. Although based on a small sample of two individuals, the findings provide relevant considerations regarding both the potential and the limitations of forensic age progression.

Subject A achieved a substantially higher recognition rate (79.1%) than Subject B (54.3%), and the difference was statistically significant. However, this difference should be interpreted with caution, given the pilot nature of the study and the extremely small sample size. Several factors may account for this discrepancy. First, differences in facial morphology may have influenced ease of recognition. Subject A exhibited a more elongated facial shape and distinctive eyebrow morphology, features that may provide clearer visual cues to observers.

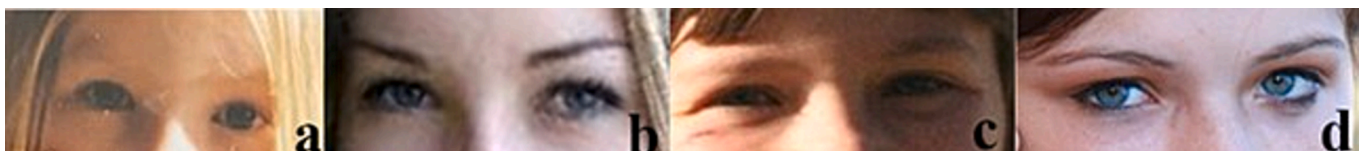


Fig. 2. Details of the eyebrows and eyes of subject A at ages 5 (a) and 15 (b), and subject B at ages 5 (c) and 15 (d).

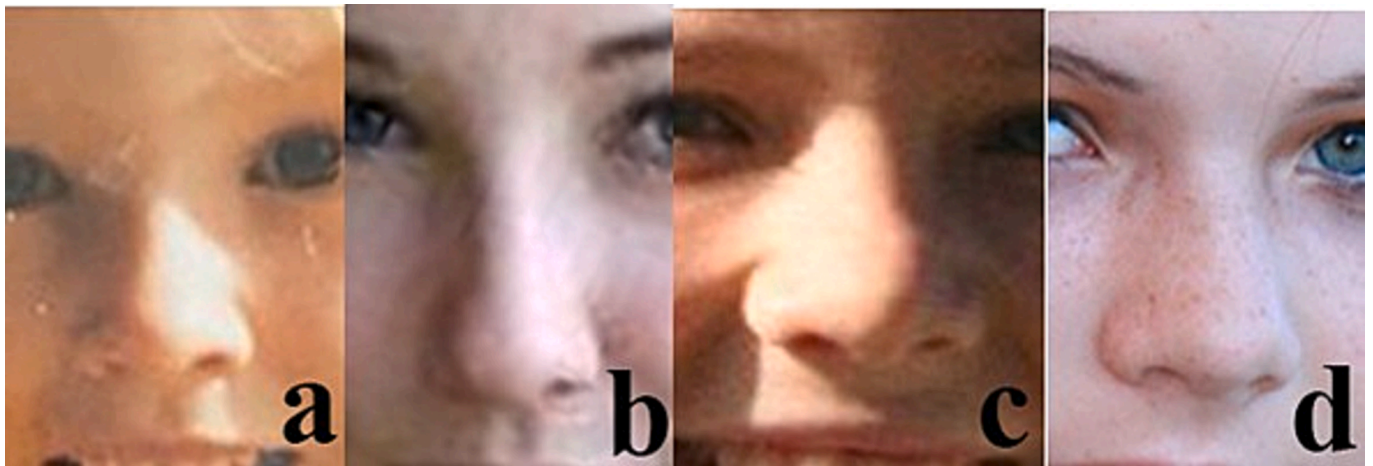


Fig. 3. Details of the nose of subject A at ages 5 (a) and 15 (b), and subject B at ages 5 (c) and 15 (d).



Fig. 4. Details of the mouth of subject A at ages 5 (a) and 15 (b), and subject B at ages 5 (c) and 15 (d).

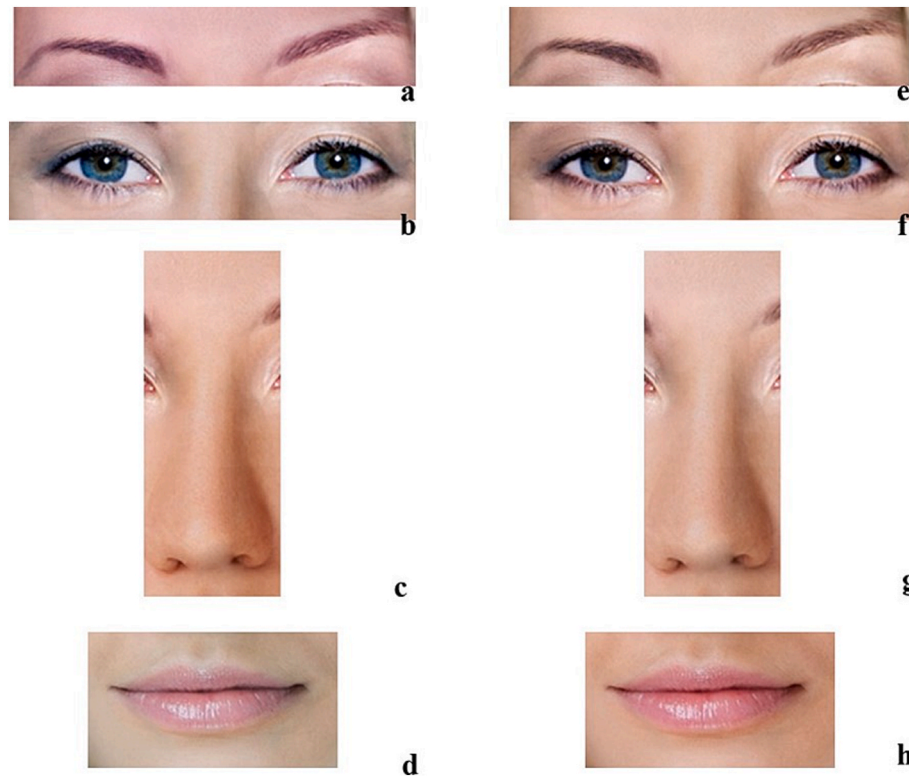


Fig. 5. Facial features of subject A before (a–d) and after (e–h) tonal value correction: eyebrows (a, e), eyes (b, f), nose (c, g), and mouth (d, h).

In contrast, Subject B displayed a rounder facial outline and more uniform soft-tissue contours, which may offer fewer distinctive markers and thus complicate identification. This interpretation aligns with psychological research demonstrating that recognition based on unfamiliar

faces is particularly fragile and sensitive to subtle variations in feature shape and configuration [24].

Second, characteristics of the input photographic material may have affected age-progression accuracy. Subject B's childhood photograph

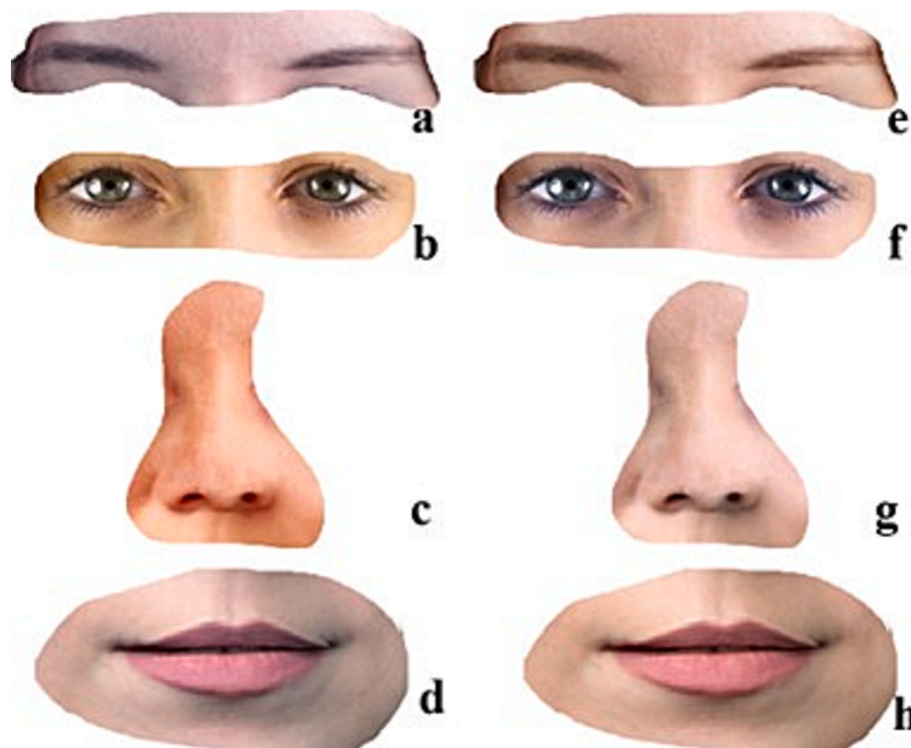


Fig. 6. Facial features of subject B before (a–d) and after (e–h) tonal value correction: eyebrows (a, e), eyes (b, f), nose (c, g), and mouth (d, h).



Fig. 7. Current appearance (a, c) and age progression (b, d) of subject A (a, b) and subject B (c, d).

Table 1
Distribution of participant responses for the recognition task.

Response category	Subject A	Subject B
Correct answers	83 (79.1%)	57 (54.3%)
Incorrect answers (given)	4 (3.8%)	26 (24.8%)
No answer	18 (17.1%)	22 (20.9%)

showed more pronounced light imbalance, which may have obscured subtle traits important for predicting adult morphology. Prior studies indicate that input image quality is a critical determinant of the accuracy of facial approximations and age-progressed images [12–18].

The qualitative comparison between the age-progressed images and the subjects' current images revealed that several morphological traits were successfully approximated—such as face shape, eyebrow configuration, and general nasal morphology—while discrepancies were

observed in finer details. These differences may reflect the combined influence of individual developmental variability, soft-tissue aging, environmental exposures, and the limitations inherent in predicting adult facial appearance from early-life photographs [16].

Interpretation of the recognition task must also consider the extensive literature on unfamiliar-face recognition, which consistently shows that individuals are generally poor at identifying faces they do not already know [24]. Studies such as Lampinen et al. (2012) further report that age-progressed images may be particularly challenging to match under unfamiliar-face conditions [25]. The ecological setting of this study—where participants had no prior familiarity with the subjects and were not trained in facial comparison—likely magnified these difficulties.

Overall, the findings indicate that while forensic age progression can preserve key morphological characteristics, its effectiveness is influenced by the distinctiveness of individual facial traits, the quality of the source images, and the context in which the images are evaluated. This

underscores the need for more rigorous, systematically controlled studies to improve the reliability and forensic applicability of age progression in missing person investigations.

The contribution of this study should be understood as applied empirical validation rather than methodological advancement, providing preliminary data to inform larger, systematically controlled future investigations.

4.1. Limitations

This study has several limitations. First, the sample size was extremely small, involving only two subjects, and therefore the results cannot be generalized. Second, the recognition task was conducted in an uncontrolled ecological setting, which may have introduced variability in lighting, viewing conditions, and participant attention. Third, all participants were untrained individuals, reflecting real-world public recognition contexts but not forensic examiner performance. Finally, the quality and characteristics of the input photographs may have influenced age-progression accuracy.

Future studies should include larger and more diverse samples, standardized testing conditions, trained evaluators, and, when possible, higher-quality input images. The integration of quantitative approaches and emerging technologies may further improve the reliability of forensic age progression.

5. Conclusions

This pilot study offers preliminary evidence regarding the recognizability of forensic age-progressed images derived from childhood and adolescent photographs. Within these constraints, the present findings should be interpreted as hypothesis-generating rather than confirmatory. While several morphological traits were successfully approximated, recognition performance varied substantially between subjects, reflecting the influence of individual facial distinctiveness, input image quality, and the challenges inherent in unfamiliar-face recognition. These findings highlight both the potential and the limitations of current age-progression techniques and emphasize the need for larger, systematically controlled validation studies. Strengthening methodological rigor in this field is essential to enhance the reliability and forensic value of age progression in long-term missing person investigations.

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Disclaimers

The views expressed in the submitted article are our own and not an official position of the institution.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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