Emerging researcher article

Juvenile age estimation from facial images

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ABSTRACT

Age determination from images can be of vital importance, particularly in cases involving suspected child sexual abuse (CSA). It is imperative to determine if an individual depicted in such an image is indeed a child, with a more concise age often sought, as this may affect the severity of offender sentencing.

The aims of this study were to establish the accuracy of visual age estimation of the juvenile face in children aged between 0 and 16 years and to determine if varying levels of exposure to children affected an individual's ability to assess age from the face. An online questionnaire consisting of 30 juvenile face images was created using SurveyMonkey®.

The overall results suggested poor accuracy for visual age estimation of juvenile faces. The age, sex, occupation and number of children of the participants did not affect the ability to estimate age from facial images. Similarly, the sex and age of the juvenile faces did not appear to affect the accuracy of age estimation. When specific age groups are considered, sex may have an influence on age estimation, with female faces being aged more accurately in the younger age groups and male faces more accurate after the age of 11 years, however this is based on a small sample.

This study suggests that the accuracy of juvenile age estimation from the face alone is poor using simple visual assessment of images. Further research is required to determine exactly how age is assessed from a facial image, if there are indicators, or features in particular that lead to over- or under-estimation of juvenile age.

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1. Introduction

Age estimation in the living can be carried out physically via the skeletal analysis of wrist x-rays, dental development or through the assessment of the Tanner stages of sexual maturation [1,2]. However, when only a photographic image is available for consultation this process becomes significantly more challenging. In cases involving pornographic images suspected to depict children, it is of great importance to be able to assess if the individual in the image is indeed a child, thus indicating the crime of child sexual abuse (CSA) [3]. A more precise age is often required to determine the severity of offender sentencing and may be used in the identification of the victim [4,5]. Age evaluations could aid the sequencing of images, when there are several images present which have been taken over a period of time [6].

The availability of child pornographic images has grown exponentially with the development of the internet resulting in millions of images of CSA, which are shared and downloaded online [4,7,8]. Consequently, there has been a rise in the number of cases in which an expert has been called upon to give an age assessment from a photograph of alleged CSA [4,5]. Experts may include individuals such as paediatricians, gynaecologists, forensic pathologists or forensic anthropologists [3,4], although this remains a very contentious area with only very recent attempts to provide guidelines for use in age estimation from photographic images [9–11].

Visual assessment of age from pornographic images has been based on the evaluation of the Tanner stages of development and other sexual maturity indicators, with the face also suggested to be an important feature for analysis [8,12]. However, studies have shown that age estimation from secondary sexual characteristics is inaccurate, with wide variability in the choice of features believed to be most important in age assessment [8]. Growth and sexual maturation can be affected by many factors such as environmental factors, obesity and malnutrition, population differences and even individual biology can influence the rate and timing of sexual maturation [4,5,13]. In addition, the assessment of sexual maturation may be confused, as adults may remove features such as pubic and axillary hair in order to appear younger.

The use of anthropometrics to estimate the age of a child from facial photographs has been tested by a group of European researchers [6,13]. These studies have been carried out with the aim of being able to define an age, or age range from the faces of individuals present in images of alleged child pornography. Cattaneo and colleagues conducted a pilot study into the use of facial proportions as a method of estimating age [3]. They achieved an average accuracy of 60.3% individuals placed

into the correct age group. However, they only used four age groups based on images of individuals at 6, 10, 14 and 18 years. As they only studied individuals at single ages, with a four year gap between groups, this may have accentuated the differences between individuals from each of the groups and the true differences between individuals at each year between 6–18 years may not be significantly different.

A more recent study [13] found 7 anthropometric indices which show a correlation with age of 0.7 or above, with no relevant differences between male and female face measurements. The authors noted that the use of photo-anthropometry is cautioned against and suggested that pose differences may affect the comparison of facial indices. Videos and images of CSA are often low quality, many being recorded on mobile phones, and faces may be captured from varying angles, poses and distances from the camera [6]. These differences make it difficult to directly compare measurements, such as proportions and distances between features, to the standards created in these studies for each age, or age group. Moreover, the facial landmarks from which measurements are taken may not be readily visible in lower quality images. The placement of facial landmarks have already been shown to display varying degrees of inter-observer error, even when placed on high quality images [8].

Anthropometric methods concerning juvenile ageing from the face have shown promising results, but may not be applicable to low quality images, or when there are significant variations in pose or expression, while automated methods of facial ageing are still restricted in their ability to classify juvenile facial age with any real precision [14]. A recent study demonstrated the ability of an automated system to estimate age with a mean absolute error of 1.47 years. Visual assessment of age was also made by experts and lay-persons with mean absolute errors of 1.63 and 1.84 years respectively, however, only female children aged between 10–19 years old were considered in this study [6].

The current study aimed to assess human ability to estimate juvenile age from facial photographs of children aged between 0–16 years. In particular, differences in accuracy of age estimation were assessed for faces of different ages and for both sexes. White European face photographs were used in this study, as facial ageing can vary between populations and there is evidence that an own-race effect may exist in age estimation of faces, similar to that found in facial recognition, although this has not been tested extensively [15]. Increased exposure to juveniles through working or living environments was recorded in order to test the hypothesis that, "participants who spend more time in the presence of juveniles of varying ages will score higher accuracy in the estimation of age from juvenile faces."

2. Materials and methods

An online questionnaire was created using SurveyMonkey® and consisted of a selection of 30 face photographs of white European children covering the age range 0–16 years, with equal numbers of male and female faces. The images were taken from a larger database of known-age images provided retrospectively by adult participants (99 female and 141 male). The database consisted of multiple images (mode = 4) of each participant between the ages of 0–16 years, with a total of 1623 images across all individuals. The images were a mixture of black and white (n = 5) and full colour (n = 25), frontal face photographs. These varied in quality as photographs were collected retrospectively and thus image acquisition could not be controlled. Where possible, full frontal face images of good quality, with close to neutral expression were utilised. All images were cropped, using Adobe Photoshop CS5.1, so that only the face and hair remained (see Fig. 1). This was to ensure that only the face and head were considered for

Fig. 1. (Top image) Example of single age type question; (bottom image) example of age range type question.