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## When age-progressed images are unreliable: The roles of external features and age range☆

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### ABSTRACT

When children go missing for many years, investigators commission age-progressed images from forensic artists to depict an updated appearance. These images have anecdotal success, and systematic research has found they lead to accurate recognition rates comparable to outdated photos. The present study examines the reliability of age progressions of the same individuals created by different artists. Eight artists first generated age progressions of eight targets across three age ranges. Eighty-five participants then evaluated the similarity of these images against other images depicting the same targets progressed at the same age ranges, viewing either whole faces or faces with external features concealed. Similarities were highest over shorter age ranges and when external features were concealed. Implications drawn from theory and application are discussed.

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### 1. Introduction

Recovering missing persons is a major challenge for law enforcement organizations, especially when the missing person is a child. Although most missing children are recovered quickly (within 3 to 72 h), an important subset of cases see children missing for many years, and sometimes decades [10]. In these cases, helpful leads decrease exponentially as time progresses, substantially reducing the probability of the child's recovery [21]. One technique employed by members of law enforcement to generate new leads for these cases is to produce age-progressed images that approximate the appearance of the child at a later age. These images are then disseminated to the media so that the public can see them and potentially aid in the children's recovery.

Although techniques to create age progressions vary, the general method is for artists to incorporate knowledge of average craniofacial morphogenesis as well as images of the children's parents at various ages to narrow down the predicted appearance [32]. Any methods beyond this are idiosyncratic among artists [17]. Moreover, faces mature and age in generally predictable ways, so one might expect artists striving to create photorealistic images of a person's future appearance to

create similar renditions. In the current paper we present a study aimed at determining the reliability of results produced by similar age-progression training on the age progressions themselves.

#### 1.1. Laboratory studies of age progressed images

Rendering age-progressed images has some intuitive appeal and is widely used in missing persons' cases. However, systematic laboratory studies investigating how recognizable these images are have not produced promising results [4,16,19], finding that outdated images of the children lead to recognition of the older individual just as well as age progressions themselves.

In the first study investigating how well age-progressed images lead to correct identifications, Lampinen, Arnal, et al. [16] obtained childhood photographs of volunteers at ages 7 and 12, as well as biological relatives at these ages. Professional forensic artists then created age progressions of the 7-year old images up to age 12. Participants studied four outdated images, four current age 12 images, or age progressions and were then given a task to organize photos of 12-year old children into two teams. Within the set of images were the targets studied previously, and participants were told to indicate if they recognized any image from the study phase. Subsequently, participants viewed four lineups containing the study images as well as plausible decoys (foils). For both measures, current images led to correct identifications more often than age progressions and outdated images, which in turn did not reliably differ from one another. A second experiment modified this procedure by presenting outdated images alongside age progressions, which is more often the actual practice. Still, this condition did not differ from

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outdated images. It is perhaps worth mentioning that outdated images led in some cases to more recognitions than age progressions, although this benefit was not reliable.

Lampinen et al. [19] extended this research using images from a real case where the child was recovered after many years, but still found the age progressions produced equivalent recognition to outdated images. Concerned that Lampinen and colleagues' paradigm might be too difficult for participants, Charman and Carol [4] conducted a series of more classical identification studies wherein participants merely viewed images and then attempted to identify the targets from lineups. Their results again showed that age-progressed images produce less correct identification than current and outdated images; in this case, however, age progressions actually produced increased false identifications. The authors interpreted this result as demonstrating that age-progressed images increase the number of plausible targets whose appearance they might match.

### 1.2. Challenges to predicting future appearances

In light of the research outlined in Section 1.1, it is clear that attempting to render an accurate prediction of someone's future appearance is a challenging task. Facial appearance can change in many different ways, increasing the amount of error in prediction. When discussing this sort of error, it is useful to consider validity and reliability. With age progressions, validity refers to whether a progression performs its intended purpose; namely, whether it is a plausible future likeness of an individual. The aforementioned experiments focused on the validity of age progression as a methodology—that is, do the resultant images match the actual appearance of the target individual? Generally, the research has found this to be the case, although matches are no more representative of current appearance than outdated images. Reliability refers to whether the process of age-progression produces the same results across different forensic artists. Of course, some variability is expected with any tool or form of measurement, and minimal error is acceptable. Extreme variability such that two age progressions of the same person are actually dissimilar from one another should be of concern to proponents of the method and might draw the reliability of the method into question. It is this latter matter of reliability between artists that is the focus of the current paper.

Because over 55% of missing persons cases go unresolved [23] and 85% of unidentified remains remain so [24], artists rarely receive feedback on how well their predictions matched the person's veridical appearance. Therefore, determining the causes of variability in a controlled setting could lead to more refined methods for the generation and implementation of age-progressed images. In Section 1.3.1 we outline some of what we believe are the major contributors of variance among age progressed images.

#### 1.2.1. Natural and lifestyle factors over time

Growth patterns of human faces follow similar and predictable sequences of changes throughout life [1,9]. For this reason, forensic artists commonly take into account average developmental patterns. There is nonetheless individual difference in the exact timing and magnitude of the various changes that occur, which is why artists also typically use family members' images as a guide to how the child may appear at different age points. Beyond this, lifestyle and environmental factors such as diet, drug use, and sun exposure can incur unpredictable changes to a person's appearance [1]. These factors compound and interact with natural morphogenesis as the person remains missing for many years.

From a face space account [33,34], the myriad age-related facial changes would render faces further distinct from their younger iterations because they exaggerate shape and texture. Indeed, older faces do resemble caricatures of their younger selves [14]. So, although a forensic age progression is an informed prediction, it remains subject to error similar to a statistical point estimate within face space.

Importantly, individual forensic artists may be biased to posit a similar or different prediction from other artists given the exact same starting materials.

Lampinen, Erickson, Frowd, and Mahoney [18] manipulated the age range artists were tasked with creating progressions, varying from ages 5 to 12 years, 5 to 20 years, and 12 to 20 years for eight individuals. Average age progressions were also generated by morphing the four progressions made for each individual at each age range. Participants then compared progressions and morphs in pairs alongside their intended targets' older ages and description-matched foils, rating their similarities on scales of 1 (extremely dissimilar) to 7 (extremely similar). Similarity ratings for images varied by artist, although shorter age ranges produced progressions more similar to targets than did longer age ranges. This is a sensible finding because age range would contribute to variability for the reasons stated earlier in this section – more time allows for more natural and lifestyle changes in facial appearance. Importantly, morphs produced more similar depictions than average ratings collapsed across all artists, likely because morphs minimized idiosyncratic features depicted by individual artists as in composite sketches [3]. This indirectly indicates that inter-artist reliability for images of the same targets negatively affects target similarity.

#### 1.2.2. Hairstyle changes

A person's appearance can vary widely on a day-to-day basis as well. Of course, overt disguises by those not wishing to be recognized can hinder accuracy [29]. Researchers have found elsewhere in the forensic science and eyewitness memory literatures that changes in external features – especially hairstyle – can influence face perception [8] and even hinder it [2,22,28]. In the related literature examining forensic composites of wanted fugitives, reducing the likeness of a suspect's hairstyle has been found to reduce correct naming rates of the composites [12,13]. In this case, hairstyle is meant to match a witness's memory of a perpetrator. However, in the case of age-progressions, hairstyles are arbitrarily chosen by the forensic artist and different artists might choose very different styles for the same individual. So, the variability of age-progressions for the same target might originate in variability in hairstyle. For this reason, we examine the effect of external features such as hairstyle on perceptions of age-progressed images made by different artists in the current study.

#### 1.2.3. Artist experience and training

A final contributor to age progressions' variability is that artists have different levels of training and experience. The effect of different levels of training on age progressions has never been examined before, but Davies and Little [6] explored the effect of expertise on forensic composites (i.e., images of perpetrators or abductees generated from an eyewitness's description). Police sketch artists and art students each sketched likenesses of six faces. Police sketch artists' images were rated as more faithful likenesses by independent judges who were blind to condition. So, specialized forensic training does produce more faithful likenesses in the composite domain. But does experience help predictions of future appearance?

Another factor related to experience is precise methodology: does the artist sketch by hand, use photographic manipulations via computer, or some combination of both? Frowd, Carson, et al. [11] compared naming rates of forensic composites made either via sketch or a number of computerized systems. Computerized systems, which produce more photorealistic images, were spontaneously correctly named by participants more often than sketches. However, sketches performed better than other methods when targets were average-looking. In the current study, we focused on human artists' performance creating age-progressed images because they are still almost exclusively conscripted by law enforcement and advocacy groups for these types of forensic images. Also, little is known about how their techniques (e.g., focusing on internal vs external features) affect image variability. We surveyed each artist participating for their style and methods. No two artists work

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