

Overview

In 2014, NIJ grant #2014-DN-BX-K007 was awarded to an international team (PI: GR Milner, Co-Pls: JL Boldsen and SD Ousley) to identify and characterize new ageinformative skeletal traits in modern populations and investigate analytical approaches for generating accurate and precise age estimates. As of 2018, their reference dataset contains approximately 1,700 documented individuals from five skeletal collections.

A trait manual and associated data collection form are publically available¹. Method and software development are ongoing, but a preliminary program (TA3 Beta Ver. 0.8.0)² has been released for public testing (Fig. 1).



Figure 1. TA3 trait manual, generic data collection form (front and back), and TA3 (Beta Ver. 0.8.0) data entry screen.

This research evaluates the software's performance on two international samples to assess its efficacy for forensic use and to contribute to ongoing method development for estimating age using TA3 data.

TA3 trait data² were collected for a total of 511 individuals from the University of Athens Human Skeletal Reference Collection (n=202) and g Santiago Subactual Osteology Collection (SSOC) (n=309) (Fig. 2).

Athens data were collected by SMG, a member of the original NIJ-funded TA3 research team, while SSOC data were collected by JG, who received hands-on training by SMG prior to Figure 2. Age and sex distribution of the combined (N=511) (left) and data collection.

Test Samples



contributing Athens (n=202) and SSOC (n=309) test samples (right) used to evaluate the performance of TA3 (Beta Ver. 0.8.0).

¹ Milner GR, Ousley SD, Boldsen JL, Getz SM, Weise S, and Tarp P. 2019. "Transition Analysis 3 (TA3) Trait Manual." Public Distribution Version 1.0. https://www.statsmachine. net/software/TA3/docs/TA3 Trait Scoring Manual 1.0.pdf

² Richardson R and Ousley SD. 2021. Transition Analysis 3 (version 0.8.0). https://www. statsmachine.net/software/TA3/.

The Evaluation of the Transition Analysis 3 (TA3) (Beta Ver. 0.8.0) **Age-Estimation Program Using Two International Samples** Sara M. Getz¹ and Jacqueline Galimany²

¹University of Wisconsin-Platteville, Dept. of Criminal Justice & Social Sciences; ²Independent Researcher

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Methods

TA3 Age-Estimation Method

Despite its name, the TA3 Beta Ver. 0.8.0 program uses a different approach for estimating age than the "transition analysis" method used in TA2 (ADBOU).

In the current TA3 approach, a random generalized linear model (RGLM) predictor (R package "randomGLM") is trained using a portion of the TA3 reference sample and then applied to the unknown skeleton to generate a point age estimate. Intervals are produced using the loess.sd function (R package "msir") which generates variability bands for the age estimates from the RGLM using Local Polynomial Regression.

Program Evaluation

In our test sample (Fig. 2), age was estimated for each individual by:

- (1) directly entering data into the TA3 software OR
- (2) executing the ta3.R analysis file modified to allow for batch analysis and extraction of associated analytical data (https://github.com/jgalsku/TA3eval)

sample of individuals was analyzed using both methods to ensure that identical results were produced.

Accuracy (documented age was within estimated 95% interval), bias (directional error of point estimate), and precision (length of 95% interval) were evaluated for the individual and combined test samples.

References

³ Getz SM and Byrnes PD. 2021. Testing the Traits of TA3: Setting a Baseline for Method Development & Performance. Poster. *Proceedings of the American* Academy of Forensic Sciences 27:55.

Results

Accuracy for the combined sample was 84.5%; however, accuracy was significantly lower for individuals under 40 years (57.0%, 73/128) versus those 40 years and older (93.7%, 359/383) (Fig. 3).



differences Despite completeness the individuals in the two analyzed samples, accuracy for each sample was similar: SSOC 86.7% (268/309) and Athens 81.2% (164/202).



Figure 3. Accuracy of estimated point age (triangle) and interval (vertical line) for each estimate.

Bias was present in the point estimates, particularly individuals younger (<40 years) and with more complete skeletons (Athens sample). Between 40 and 80 years of age, a mix of over- and under-estimation occurred, with a trend of increased underestimation with advancing age (Fig. 4).



Figure 4. Bias [estimated age - documented age] of estimates by age group. Red line indicates no bias.

individuals Precision for under the age of 40 was poor (average 27.4 years), while precision for individuals 40 years and older was similar to existing methods (average 36.9 years) (Fig. 5). Intervals with a width of zero (0) were estimated for six individuals from both samples using both input methods.



Acknowledgements

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Discussion

Training Samples: RGLM, as implemented in the TA3 software, trains the age-estimation model with only individuals that have all of the traits entered for the unknown individual. This results in a negative correlation between skeletal completeness and training sample size (Fig. 6).

However, no relationship could be found between training sample size and accuracy in the combined sample. Details other than the sample size (e.g., sex, age, collection) of the selected training sample are not provided, which hinders evaluation of the results.



Figure 6. The more traits that are present for an individual, the smaller the sample size used to train the ageestimation model.

Bias & Precision: Using the same Athens test sample, previous research³ has demonstrated that combining TA3 traits in a "transition analysis" framework increases estimate precision with no systematic age-estimation bias. This indicates the TA3 software analytical approach may be at fault, not the traits and reference data.

Conclusions

TA3 (Beta Ver. 0.8.0) is currently inappropriate for use in forensic or archaeological contexts and should be modified before stable release. Alternative analytical approaches that utilize the full TA3 reference dataset should be evaluated.

Updates: TA3 (Beta Ver. 0.8.5), released Oct. 2021, was tested and produces identical results. An updated trait manual (Ver. 2) with additional images is also under development.

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