

Facial Resemblance of Children to Parents

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Hypothesis

To examine if there is a significant **prevalence** within a population in the facial resemblance of offspring to **paternal parent** over **maternal parent** (Christenfeld and Hill, 1995), by quantitatively comparing **facial landmarks** to both parents using a series of facial recognition and analysis programs.

Background



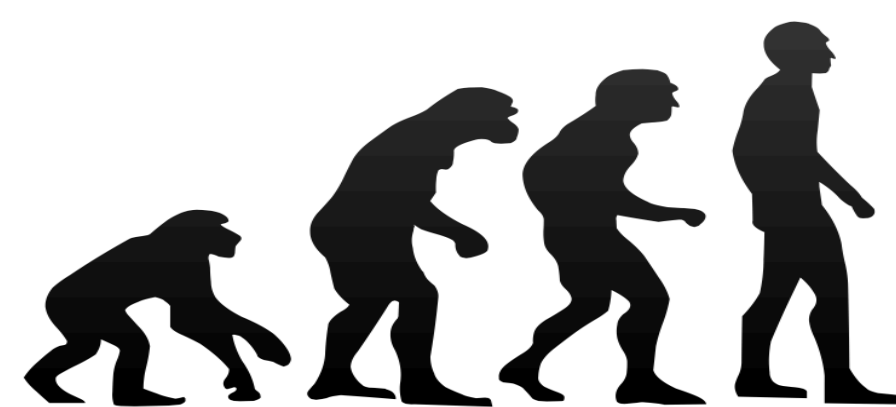
Figure 1.0 Scientists confirm that 5 genes (or gene loci) have been found that are responsible for the development of different facial structure formations. For instance, PAX3 is involved in determining the distance between the nasion (Nsn) and the eyes by facilitating muscle-cell formation. This is exemplified by the genetic basis for Waardenburg syndrome, which leads to wide-set eyes. (Liu, Fan, et al. "A genome-wide association study identifies five loci influencing facial morphology in Europeans." *PLoS Genet* 8.9 (2012): e1002932.)

Quantitative Resemblance

Approach: Facial Landmarks

- It had been suggested that 5 facial features could be linked with 7 genome areas: face width, nose width and depth, distances between eyes, and depth of face.
- Suggesting this formation distance is genetic, suggests that it is also inheritable.
- 2-D facial landmarks were marked and analyzed: the distance between the nasion and the outer corner of the eyes, the nose width, and the face width, using photos of family members of 30 parent-offspring relationships in a Canadian-Egyptian community.
- The program used to analyze differences between 2D configurations (of digitized human facial landmarks) is Procrustes analysis of Image Configurations (PICs) designed by Dr. Xia Xuhua.
- Based on the distance measurements, the program reports which resemblances are greater by forming a genealogical tree based on the calculated residual sum of squares (RSS) and $\text{Dist}=\sqrt{\text{RSS}}$.

Evolutionary Theory



It has been proposed that natural selection would favour a child that looks like his/her father since this assures the father of his paternity and encourages their investment in the child, as opposed to a child who does not bear resemblance to their father, which could lead to the paternal parent's uncertainty and his withholding of resources, or even negligence/violence.

By the same logic, natural selection would favour against a child that **does** look like their father, in cases of promiscuous reproduction. Since this could lead to aggression towards the child, in this case it would then be evolutionary advantageous for the child to **not** look similar to his/her biological father.

An alternate, more advanced hypothesis, from that of Christenfeld and Hill's, could be that children will look more like their biological father in societies with little extramarital mating, but will look less like their biological father in societies with frequent extramarital mating.

Methods

To determine the quantitative resemblance between father-child and mother-child, individual photos were taken of family members within 25 Egyptian families, and digitized by manually marking down facial landmarks (1. Nasion 2. Inner corners of eyes 3. Outer corners of eyes 4. Base of nose 5. Outer nostrils) using a Web Plot Digitizer and then afterward Procrustes analysis to calculate the distance between facial landmarks between father-child and mother-child.



Figure 2.0 An example of the markings (red plots) made on facial landmarks for each family. Shown is the father (top left), mother (top right), daughter (center, bottom) for Family 1.

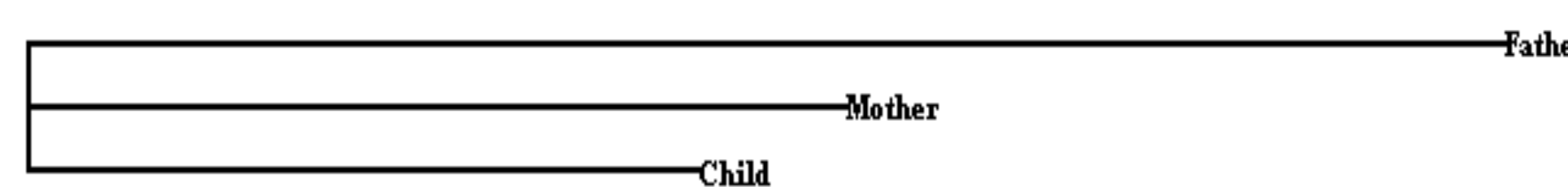


Figure 3.1 Genealogical tree synthesized by the PICs program, when the marked digitized images in Figure 2.0 (in the form of $S \times y$ plot coordinates) were processed by the program. The distance between two members in the tree is a visual representation of the differential distances between their respective facial landmarks. Since in this family's tree, the child is represented to be a greater distance away from the father than the mother, it can then be concluded that the ratio of the child's facial landmarks are more similar to that of the mother. For this family the reported values of the father-child difference is 0.4636 and mother-child difference is 0.3189. The difference between mother and father (unrelated) is 0.4964.

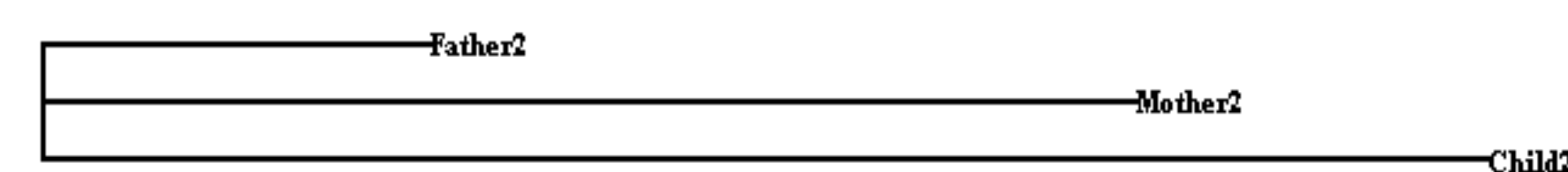


Figure 3.2 Genealogical tree synthesized by PICs program for Family 2. For this phylogenetic tree, the father is lesser distance away from the child than the mother, suggesting a greater resemblance in facial landmark ratio of the child to the mother, than father for Family 2. For this family the reported values of the father-child difference is 0.3645 and mother-child difference is 0.5023. The difference between mother and father (unrelated) is 0.29014. A greater "resemblance" may be due to their similar age, as facial feature ratios may change with age.

Results

- The results were inconclusive; from the data it could be suggested that there may be a greater resemblance of children to their mothers, since the **average distance** between facial landmarks of **mother-child** were **lower** than the average distance between landmarks of **father-child**, however this resemblance was **not statistically significant** as the calculated p-value was 0.20 (it is required that $p < 0.10$ for it to be considered significant data.)
- It must then be concluded that **there is no statistically significant difference between the resemblances between mother-child and father-child.**
- This aligns with the results obtained by a study done by D. Kelly McLain and Deanna Setters (1998), Serge Brédart and Robert M. French (1999), Paola Bressan, and Massimo Grassi (2003) on resemblance of children to parents, which all found there to be an **equal probability of resemblance of children to their fathers as to mothers**, contradicting Christenfeld and Hill's findings (1999).
- The contradiction between those studies and this study was that it could **not** be concluded that the difference in facial measurements of **mother-child** or **father-child** was **less** than that of unrelated family members (mother-father) with a p-value of 0.3 and 0.5 respectively. This may be because ratio of facial landmarks may change with age, suggesting why unrelated members that were more similar in age (mother-father) were as **similar in resemblance as mother-child or father-child.**
- It is important to note that the measurements were simply taken from a 2-D image, as opposed to a 3-D MRI scan, and that facial landmarks were limited in accuracy, especially because the landmarks were manually and superficially plotted, i.e. the nasion is a landmark that can only be approximated.
- It is likely that variation of facial feature development, (in terms of distance between eyes and nose width and distance from nose to eyes,) is not variable or unique enough in a population to reflect heredity. For instance, many unrelated individuals can have the same facial feature ratios. Using more facial landmarks, such as the top of the head, the chin, or the zygomatic arch, may give more reflective results.

Similar Studies

Studying resemblance between family members is still in early stages of research. Previous studies dealt with qualitative resemblance, while this study attempts to determine quantitative resemblance (facial feature measurements.) The hypothesis for our experiment was that children would resemble their fathers more than their mothers (Christenfeld and Hill, 1995). However, this study, as well as several other studies have failed to replicate the results of Christenfeld and Hill.

- A similar study by Serge Brédart and Robert M. French concluded with similar results; that children aged 1, 2 and 5 do not appear to resemble their fathers more than their mothers.

They note that "any father-child resemblance that does exist, although better than chance, is far from overwhelming." (Brédart and French, 1999).

Bibliography

- McLain, D. K., Setters, D., Moulton, M. P., & Pratt, A. E. (2000). Ascription of resemblance of newborns by parents and nonrelatives. *Evolution and Human Behavior*, 21(1), 11-23.
- Brédart, S., & French, R. M. (1999). Do babies resemble their fathers more than their mothers? A failure to replicate Christenfeld and Hill (1995). *Evolution and Human Behavior*, 20(2), 129-135.
- Bressan, P., & Grassi, M. (2004). Parental resemblance in 1-year-olds and the Gaussian curve. *Evolution and Human Behavior*, 25(3), 133-141.
- Hill, E. A. (1995). Whose baby are you?. *Nature*, 378, 14.
- Liu, Fan, et al. "A genome-wide association study identifies five loci influencing facial morphology in Europeans." *PLoS Genet* 8.9 (2012): e1002932.